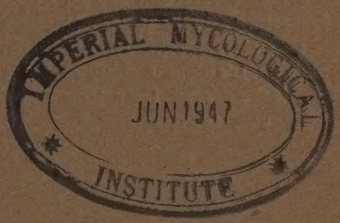
COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

NOUVELLE SÉRIE

1944



VOLUME XLII

№ 5

ÉDITION DE L'ACADÉMIE DES SCIENCES DE L'URSS
MOSCOU

AVIS AUX AUTEURS

Les «Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS» paraissent tous les dix jours. Neuf numéros composent un volume pourvu d'une table des matières. Il y a quatre volumes par année.

Les «Comptes Rendus de l'Académie des Sciences de l'URSS» en de courtes communications précisent l'essentiel des travaux en préparation. Ces articles, ne dépassant pas en règle générale quatre pages, sont donnés en anglais, en français ou en allemand. Ils embrassent les sciences mathématiques, physiques, naturelles et appliquées, mettant au jour les résultats de recherches scientifiques en cours ou qui viennent d'être achevées, et représentant ainsi les plus récentes données de l'investigation scientifique.

L'auteur a droit à 50 exemplaires de son article.

Adressez les manuscrits à la Rédaction des «Comptes Rendus», Moscou, Wolkhonka, 14.

20 Février

COMPTES RENDUS

(DOKLADY)

DE L'ACADÉMIE DES SCIENCES DE L'URSS

COMITÉ DE RÉDACTION

A. Arbusov, de l'Académie, **A. Borissiak**, de l'Académie, **V. Chlopin**, de l'Académie, **A. Deborin**, de l'Académie, **A. Fersman**, de l'Académie, **A. Frumkin**, de l'Académie, **A. Kolmogoroff**, de l'Académie (vice rédacteur), **L. Orbeli**, de l'Académie (rédacteur en chef), **A. Richter**, de l'Académie, **S. Soboleff**, de l'Académie, **S. Wawilow**, de l'Académie (vice rédacteur)

NOUVELLE SÉRIE

12-me année

Paraissant tous les dix jours

1944

VOLUME XLII, № 5

TABLE DES MATIÈRES

Pages

MATHÉMATIQUES

I. Gelfand and **D. Raikov.** Irreducible Unitary Representations of Locally Bicompact Groups 199
Ch. Nougmanova. Sur la stabilité des mouvements périodiques 202

HYDROMÉCANIQUE

I. A. Charny. Flow of Oil to Wells in Reservoirs of Oval and Crescent Form 205

PHYSIQUE MATHÉMATIQUE

I. S. Koukless. Sur quelques cas de distinction entre un foyer et un centre . 208

CHIMIE

W. A. Ismailski. Contribution to the Problem of a Water-soluble Camphor, «Camphor Vi» 212

CHIMIE DU GLOBE

T. F. Borovick-Romanova. On the Rubidium Content of Sea Water 216
G. I. Theodorovich. On the Geochemistry of the Petroliferous Deposits of the Buguruslan Region and the Outlook for Search in the Second Buguruslan 219

GÉOLOGIE

N. V. Logvinenko. On the Lithology and Palaeogeography of the Carboniferous Deposits of the North-East of the Donetz Basin 223

MICROBIOLOGIE

K. S. Sukhov. Salivary Secret of the Aphis *Myzus persicae* Sulz. and its Ability to Form a Filtering Apparatus 226

PHYSIOLOGIE VÉGÉTALE

N. A. Maximov, Corresponding Member of the Academy, and **L. V. Mozhaeva.** Age Variations of Colloid-Chemical Properties of Protoplasm in Vegetable Cells. I. Variations of Permeability and Viscosity of the Protoplasm in the Cells of Onion Scales and Heads of Cabbage. 229
A. A. Prokofiev. On the Mechanism of the Action of Heteroauxin 233

PHYSIOLOGIE

N. V. Bekauri, A. A. Danilov and **E. A. Moissejeff.** On the Question as to the Mechanism of Death Caused by Burns 238

Édition de l'Académie des Sciences de l'URSS
Moscou 1944

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

MATHEMATICS

IRREDUCIBLE UNITARY REPRESENTATIONS OF LOCALLY BICOMPACT GROUPS

By I. GELFAND and D. RAIKOV

(Communicated by A. N. Kolmogoroff, Member of the Academy, 6.IX.1943)

The purpose of the present paper is to prove the existence of a complete system of irreducible unitary representations for an arbitrary locally bicompact group. By unitary representation of a topological group G we mean a function U_g that maps G into the set of unitary operators defined in complex Hilbert space $\mathfrak{H}$ and enjoys the following two properties: 1° $U_{gh}=U_gU_h$ and 2° U_g is a strongly continuous function of g, i. e. $\|U_{g'}\eta-U_g\eta\|\to 0$ at $g'\to g$ for every $\eta\in\mathfrak{H}$.

Denote by $\mathfrak{P}$ the totality of all continuous positive definite functions on the topological group G; i. e. such functions $\varphi(g)$ that

$$\sum_g\sum_h \varphi(h^{-1}g)\,\lambda(g)\,\overline{\lambda(h)}\geqslant 0$$

for any complex function $\lambda(g)$ $(g\in G)$ different from zero only in a finite number of points g. It is well known that *if U_g is a unitary representation of the group G, then* $\varphi(g)=(U_g\xi,\xi)\in\mathfrak{P}$ for every vector ξ. If ξ is a generating vector, i. e. the vectors $U_g\xi$ span $\mathfrak{H}$, then the space $\mathfrak{H}$ is completely determined by ξ and the function $\varphi(g)$. In fact, we then know the scalar product of any two vectors: if both $\lambda(g)$ and $\mu(h)$ are different from zero only in a finite number of points, then the scalar product of the vectors $\lambda=\sum\lambda(g)U_g\xi$ and $\mu=\sum\mu(h)U_h\xi$ is

$$(\lambda,\mu)=\sum_g\sum_h \varphi(h^{-1}g)\,\lambda(g)\,\overline{\mu(h)}; \qquad (1)$$

as to arbitrary vectors, their scalar product may be determined by a limiting process. Starting from this remark, we shall now show that *every function $\varphi(g)\in\mathfrak{P}$ determines a unitary representation of the group G.* In fact, let the formula (1) define the scalar product in the set of all complex functions $\lambda(g)$, everyone of which is different from zero only in a finite number of points. Identifying those λ and μ, for which $(\lambda-\mu,\lambda-\mu)=0$, and taking the closure with respect to the norm $|\lambda|=\sqrt{(\lambda,\lambda)}$ of the linear system so obtained, we get a Hilbert space that will be denoted by $\mathfrak{L}_2(\varphi)$. Every element $g\in G$ generates a left translation T_g in $\mathfrak{L}_2(\varphi)$ defined for the functions $\lambda(h)$ by the formula: $T_g\lambda(h)=\lambda(g^{-1}h)$. As is easy to verify, the operators T_g form a unitary representation of the group G. The function $\xi_0(g)=1$ or 0, according as $g=e$ or $g\neq e$ (where e is the unit element of the group G), is a generating vector in $\mathfrak{L}_2(\varphi)$. Moreover, $\varphi(g)=(T_g\xi_0,\xi_0)$.

Let $\varphi(g)$, $\psi(g) \in \mathfrak{P}$. We shall write $\psi(g) \ll \varphi(g)$, if $\varphi(g) - \psi(g) \in \mathfrak{P}$. The function $\varphi(g) \in \mathfrak{P}$ will be called *elementary* if $\psi(g) \ll \varphi(g)$ implies $\psi(g) = \alpha\varphi(g)$.

Theorem 1. *The unitary representation T_g of the topological group G generated by an elementary positive definite function $\zeta(g)$ is irreducible.*

Proof. Let P be a projection that commutes with all T_g. Put $\psi(g) = (T_g P\zeta_0, \zeta_0)$. Then $\sum_g \sum_h \psi(h^{-1}g)\lambda(g)\overline{\lambda(h)} = (P\lambda, \lambda)$ and the inequality $0 \leqslant (P\lambda, \lambda) \leqslant (\lambda, \lambda)$ imply $\psi(g) \in \mathfrak{P}$ and $\psi(g) \ll \zeta(g)$. Consequently, $\psi(g) = \alpha\zeta(g)$, whence $(P\lambda, \lambda) = \alpha(\lambda, \lambda)$, i. e. $P = \alpha E$. Thus, the only projections in $\mathfrak{L}_2(\zeta)$ commuting with all T_g are 0 and E. This means the irreducibility of the system of operators T_g.

We also have the inverse

Theorem 2. *Positive definite functions generated by an irreducible unitary representation U_g of the topological group G are elementary.*

In the following we shall always assume the group G to be locally bicompact. Let m be the left-invariant Haar measure defined on G. Then $m(Eg) = l_g m(E)$; where l_g does not depend on E and is a continuous one-dimensional representation of the group G (1). Denote by $\mathfrak{L}_1$ the space of all measurable absolutely integrable (with respect to this measure) complex functions $x(g)$ with the norm $\|x\| = \int |x(h)|\, dh$. Every element $g \in G$ determines a left translation T_g in $\mathfrak{L}_1$: $T_g x(h) = x(g^{-1}h)$. It follows from the properties of the Haar measure that the operators T_g are unitary and strongly continuous with respect to g.

Let $x, y \in \mathfrak{L}_1$. Then $x \star y = \int x(h^{-1}g)\, y(h)\, d\, h$ exists for almost every $g \in G$, $x \star y$ belongs to $\mathfrak{L}_1$ and $\|x \star y\| \leqslant \|x\| \|y\|$. Introduce the notation $l_g^{-1}\overline{x(g^{-1})} = x^*(g)$. Then $x^* \in \mathfrak{L}_1$ whenever $x \in \mathfrak{L}_1$; and $\|x^*\| = \|x\|$, because $\int x(g)\, dg = \int x(g^{-1}) l_g^{-1} dg$ (1).

A linear functional L defined on $\mathfrak{L}_1$ will be called *positive* if $L(x \star x^*) \geqslant 0$ for all $x \in \mathfrak{L}_1$. Being a linear functional on $\mathfrak{L}_1$, L can be uniquely represented in the form $L(x) = L_\psi(x) = \int \psi(g) x(g)\, dg$, where vrai $\max |\psi(g)| = |L_\psi| < \infty$.

The positiveness of L gives: $\int\int \psi(h^{-1}g) x(g) \overline{x(h)}\, dg\, dh \geqslant 0$ for any $x \in \mathfrak{L}_1$.

A function $\psi(g)$ satisfying these two conditions will be called *integrally positive definite.*

Theorem 3. *Every integrally positive definite function $\psi(g)$ coincides almost everywhere with a continuous positive definite function $\varphi(g)$. Thus, every positive linear functional L on $\mathfrak{L}_1$ is generated by a uniquely determined function $\varphi(g) \in \mathfrak{P}$: $L = L_\varphi$.*

Proof. Suppose that $L(x) = L_\psi(x) = \int \psi(g) x(g)\, dg$. Denote by $\mathfrak{L}_2(L)$ the complete Hilbert space obtained from $\mathfrak{L}_1$ if the scalar product is defined as follows: $(x, y) = L(x \star y^*)$. Let V be a neighbourhood of e. We shall denote by $e_V(g)$ every function belonging to $\mathfrak{L}_1$ such that $e_V(g) \geqslant 0$, $e_V(g) = 0$ outside V and $\|e_V\| = 1$. The strong continuity of the operator T_g with respect to g implies $\|x \star e_V - x\| \to 0$ and, consequently, $(x, e_V) = L(x \star e_V) \to L(x)$ at $V \to e$ for every $x \in \mathfrak{L}_1$. Hence follows that e_V converges weakly to an element $\xi_0 \in \mathfrak{L}_2(L)$ at $V \to e$ and $(x, \xi_0) = L(x)$ (it is not difficult to show that e_V converges to ξ_0 even strongly). It is easy to verify that the operators T_g form a unitary representation of the group G and thus $\varphi(g) = (T_g \xi_0, \xi_0) \in \mathfrak{P}$. Let us show that $\psi(g)$ coincides with $\varphi(g)$ almost everywhere. In fact, $\int \psi(gh) e_V(h)\, dh = (T_g e_V, \xi_0) \to \varphi(g)$ at $V \to e$. On the other

hand, for every set E of finite measure

$$\int_E \left| \psi(g) - \int \psi(gh)\, e_V(h)\, dh \right| dg \leqslant \int \left(\int_E |\psi(g) - \psi(gh)|\, dg \right) e_V(h)\, dh \leqslant$$

$$\leqslant \sup_{h \in V} \int_E |\psi(g) - \psi(gh)|\, dg \to 0 \text{ at } V \to e.$$

Proceeding to the limit under the integral sign in the left-hand side, we obtain: $\int_E |\psi(g) - \varphi(g)|\, dg = 0$, whence the assertion of the theorem follows immediately.

Theorem 4. *Every locally bicompact group possesses a complete system of irreducible unitary representations.*

Proof. The totality of all positive linear functionals L_φ belonging to the sphere $|L| \leqslant 1$ forms a convex set which is bicompact with respect to the weak topology. According to a result of Krein and Milman [1], this set contains extremal points (i. e. such points thar are not inner points of any segment belonging to this set) and coincides with the minimal weakly closed convex hull over these points. $L=0$ is an extremal point. It is not difficult to verify that the functions $\zeta(g) \in \mathfrak{P}$ generating the other extremal points L_ζ are elementary and besides «normed», i. e. $\zeta(e) = |L_\zeta| = 1$.

We have thus proved that if we introduce the «weak topology» in $\mathfrak{P}$ identifying the functions $\varphi(g) \in \mathfrak{P}$ with the functionals L_φ generated by them, then every $\varphi(g) \in \mathfrak{P}$ with $\varphi(e) \leqslant 1$ belongs to the weakly closed convex hull over the normed elementary functions $\zeta(g) \in \mathfrak{P}$ and the function $\zeta(g) \equiv 0$. But it is possible to show that if a normed function $\varphi_0(g) \in \mathfrak{P}$ is the weak limit of the functions $\varphi_\alpha(g) \in \mathfrak{P}$ with $\varphi_\alpha(e) \leqslant 1$, then the latter converge to $\varphi_0(g)$ in every point. Therefore, if there were an element $g_0 \neq e$ such that $\zeta(g_0) = 1$ for every normed elementary function $\zeta(g) \in \mathfrak{P}$, we would have $\varphi(g_0) = \varphi(e)$ for all $\varphi(g) \in \mathfrak{P}$. For every element $g_0 \neq e$ of the locally bicompact group G, however, there exists $\varphi_0(g) \in \mathfrak{P}$ such that $\varphi_0(g_0) \neq \varphi_0(e)$; moreover, for any neighbourhood V of the unit element there exists a normed function $\varphi(g) \in \mathfrak{P}$ which vanishes outside V. In fact, if we take a neighbourhood W for which $WW^{-1} \subset V$ and an arbitrary function $x(g)$ such that $\int |x(g)|^2 dg = 1$ and $x(g) = 0$ outside W, then the function $\varphi(g) = \int x(g^{-1}h)\, \overline{x(h)}\, dh$ enjoys the required properties.

We have thus proved that for every $g_0 \neq e$ there exists an elementary function $\zeta_0(g) \in \mathfrak{P}$ such that $\zeta_0(g_0) \neq \zeta_0(e)$. Then for the unitary representation T_g generated by $\zeta_0(g)$ we shall have: $(T_{g_0}\zeta_0, \zeta_0) \neq (\zeta_0, \zeta_0)$ and, consequently, $T_{g_0} \neq E$. Since the element g_0 different from e may be chosen arbitrarily and by Theorem 1 the representation T_g is irreducible, our theorem is proved.

Stekloff Mathematical Institute.
Academy of Sciences of the USSR.

Received
6. IX. 1943.

REFERENCES

[1] M. Krein and D. Milman, Studia Math., IX (1) (1940).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

MATHÉMATIQUES

SUR LA STABILITÉ DES MOUVEMENTS PÉRIODIQUES

Par Ch. NOUGMANOVA

(Présenté par N. E. Kochin, de l'Académie, le 4.VIII.1943)

Dans la présente Note on donne des conditions suffisantes pour la stabilité ou la non-stabilité au sens de Ljapounoff des solutions périodiques pour les systèmes mécaniques à plusieurs degrés de liberté.

Les équations différentielles du mouvement perturbé sont en première approximation de la forme

$$\frac{dx_i}{dt} = p_{i1}x_1 + p_{i2}x_2 + \ldots + p_{in}x_n \quad (i = 1, 2, \ldots, n) \tag{1}$$

où les p_{ik} sont des fonctions bornées, continues, périodiques par rapport à t ayant 2π pour période commune.

Dans certains cas on peut juger si le mouvement est stable ou non en s'appuyant sur les théorèmes fondamentaux de Ljapounoff.

Ecrivons l'équation (1) dans une autre forme en développant les coefficients p_{ik} en séries de Fourier:

$$\frac{dx_i}{dt} = \sum c_{ik}x_k + \sum \varepsilon_{ik}x_k \tag{1'}$$

où

$$c_{ik} = \frac{1}{2\pi}\int_{-\pi}^{\pi} p_{ik}dt, \quad \varepsilon_{ik} = \frac{1}{\pi}\sum_{\nu}\left[\cos \nu t \int_{-\pi}^{\pi} \cos \nu t\, p_{ik}\, dt + \sin \nu t \int_{-\pi}^{\pi} \sin \nu t\, p_{ik}\, dt\right].$$

Supposons que les fonctions

$$U_j = \sum_k A_{jk}x_k$$

linéaires par rapport au x_j sont déterminées par les conditions

$$\sum \frac{dU_j}{dx_s}(c_{s1}x_1 + \ldots + c_{sn}x_n) = z_jU_j, \quad (j = 1, 2, \ldots, n)$$

où z_j sont les racines de l'équation caractéristique

$$\| c_{ik} - \delta_{ik}z \| = 0$$

correspondant aux équations

$$\frac{dx_i}{dt} = \sum c_{ik} x_k \tag{2}$$

que nous convenons de nommer équations sans modulation.

Nous supposerons que tous les x_j sont non nuls et différents. Alors le déterminant formé des coefficients A_{jk}

$$\Delta = \| A_{jk} \|$$

sera non nul et on peut le choisir égal à 1.

Supposons que certaines fonctions $\beta_{jk}(t)$ sont déterminées par les conditions

$$\sum \frac{dU_j}{dx_s} (\varepsilon_{s1} x_1 + \ldots + \varepsilon_{sn} x_n) = \sum \beta_{js} U_s.$$

Pour j, i déterminés nous aurons

$$\beta_{ji} = \sum_{s,\alpha} A_{j\alpha} \Delta_{i\alpha} \varepsilon_{s\alpha}$$

où $\Delta_{i\alpha}$ est le mineur du déterminant Δ correspondant à l'élément $A_{i\alpha}$.

Supposons que la fonction $V(t, x_1, \ldots, x_n)$ est déterminée de la manière suivante:

$$V = \sum_k (x_k + \bar{x}_k) U_k \bar{U}_k. \tag{3}$$

En vertu des équations (1') sa dérivée est de la forme

$$\frac{dV}{dt} = \sum [(x_k + \bar{x}_k)^2 \delta_{kj} + (x_k + \bar{x}_k) \beta_{kj} + (x_j + \bar{x}_j) \bar{\beta}_{jk}] U_k \bar{U}_j = \sum h_{kj} U_k \bar{U}_j.$$

La fonction $\frac{dV}{dt}$ sera une forme d'Hermite. Elle est définie positive en tant que forme, et au sens de Ljapounoff elle ne sera définie positive que dans le cas où les inégalités suivantes sont vérifiées:

$$h_{11} > 0, \quad \begin{vmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{vmatrix} > 0, \ldots, \begin{vmatrix} h_{11} & h_{12} \ldots h_{1n} \\ h_{21} & h_{22} \ldots h_{2n} \\ \ldots\ldots\ldots \\ h_{n1} & h_{n2} \ldots h_{nn} \end{vmatrix} > 0. \tag{a}$$

La fonction $\frac{dV}{dt}$ sera définie positive au sens de Ljapounoff si la fonction

$$W = \frac{dV}{dt} - \varepsilon \sum (x_k + \bar{x}_k) U_k \bar{U}_k = \sum [(1-\varepsilon)(x_k + \bar{x}_k)^2 \delta_{kj} +$$
$$+ (x_k + \bar{x}_k) \beta_{kj} + (x_j + \bar{x}_j) \bar{\beta}_{jk}] U_k \bar{U}_j = \sum g_{kj} U_k \bar{U}_j$$

où ε est une constante positive, sera une forme définie positive. Comme la fonction W est une forme d'Hermite, elle ne sera définie positive que si les inégalités suivantes sont vérifiées:

$$g_{11} > 0, \quad \begin{vmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{vmatrix} > 0, \ldots, \begin{vmatrix} g_{11} & g_{12} \ldots g_{1n} \\ g_{21} & g_{22} \ldots g_{2n} \\ \ldots\ldots\ldots \\ g_{n1} & g_{n2} \ldots g_{nn} \end{vmatrix} > 0. \tag{b}$$

En prenant la fonction $V(t, x_1, \ldots, x_n)$ définie par la formule (3) pour la fonction de Ljapounoff, on obtient immédiatement de ses théorèmes connus (1) propositions suivantes permettant de décider si les solutions périodiques sont stables ou non.

Théorème 1. *Si les équations différentielles du mouvement perturbé sont en première approximation telles que les racines de l'équation caractéristique correspondant aux équations sans modulation n'ont que des parties réelles négatives, et si pendant tout le temps que le mouvement dure les inégalités* (a) *ont lieu, alors le mouvement non perturbé est stable indépendamment des termes d'ordre supérieur de l'approximation.*

Si pendant toute la durée du mouvement non seulement les conditions indiquées sont vérifiées, mais encore les inégalités (b), *alors chaque mouvement perturbé pour lequel les perturbations sont assez petites, tend asymptotiquement vers le mouvement non perturbé.*

Théorème 2. *Si les équations différentielles du mouvement perturbé sont en première approximation telles que parmi les racines de l'équation caractéristique correspondant aux équations sans modulation, il existe au moins une racine dont la partie réelle est positive, et d'ailleurs les inégalités* (b) *ont lieu pendant toute la durée du mouvement, alors le mouvement perturbé est non stable.*

Manuscrit reçu
le 14. VIII. 1943.

LITTÉRATURE CITÉE

[1] А. М. Ляпунов, Общая задача об устойчивости движения, Л.—М. 1935.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

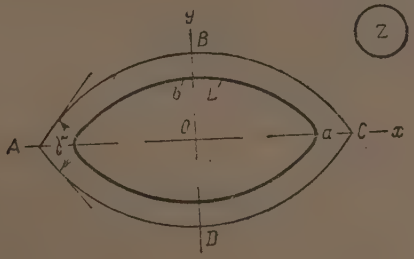
HYDROMECHANICS

FLOW OF OIL TO WELLS IN RESERVOIRS OF OVAL AND CRESCENT FORM

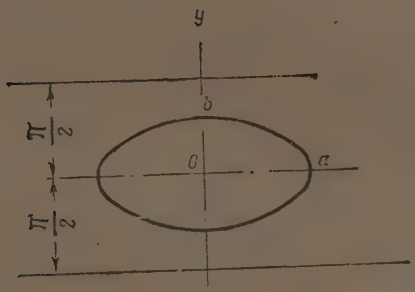
By I. A. CHARNY

(Communicated by V. G. Chlopin, Member of the Academy, I.VI.1943)

In my previous note (1) I discussed the problem of the production of wells in the reservoirs of circular and band-like form. Now we are to deal with



a



б

other forms of bed. Suppose a circle to be mapped conformably into an oval (which is not necessarily an ellipse) with given semi-axes.

Once the problem of oil inflow to wells is solved for circular beds, it will *ipso facto* be solved for oval beds, too. The functions transforming a circle into an oval may be selected in great numbers. We shall dwell here on the following method of selection. Take a triangle *ABCDA* formed on the plane z by the intersection of two circles equal in area (figure, *a*) and map it by means

of a suitable function into a circle of unit radius on the plane ζ. Then a circle of radius $\rho_n < 1$ will be mapped into an oval L, inside which ζ has no singularities. This oval L we take for the contour of the oil-bearing area.

The function transforming the biangle $ABCDA$ into a unit circle has the form

$$\zeta = \frac{1-\left(\frac{1-z}{1+z}\right)^{\varkappa}}{1+\left(\frac{1-z}{1+z}\right)^{\varkappa}} \tag{1}$$

which is obtained by assuming that

$$OA = -1, \quad OC = 1, \quad \varkappa = \frac{\pi}{\gamma}; \tag{2}$$

γ is the angle formed by intersection of circumferences. Instead of a biangle, we may take on the plane z a band of width π (figure, b) and map it into unit circle. We shall then have ovals again corresponding to the circles with $\rho_n < 1$.

The function transforming the band of width π into unit circle has the form

$$\zeta = \operatorname{th}\frac{z}{2}. \tag{3}$$

Once the problem is solved for the circle, the solution for ovals is obtained by means of (1) and (3).

For recalculating the velocities and radii of the wells we have to know the value of $\left|\frac{d\zeta}{dz}\right|$. For (1) the calculations give

$$\frac{d\zeta}{dz} = \frac{4\varkappa(1-z^2)^{\varkappa-1}}{[(1+z)^{\varkappa}+(1-z)^{\varkappa}]^2} \tag{4}$$

and, taking into account (1), we have

$$\frac{dz}{d\zeta} = \frac{1}{\varkappa}\frac{1-z^2}{1-\zeta^2} \tag{5}$$

$$\left|\frac{d\zeta}{dz}\right| = \varkappa \sqrt{\frac{(1-\xi)^2+\eta^2}{(1-x)^2+y^2}\,\frac{(1+\xi)^2+\eta^2}{(1+x)^2+y^2}} \tag{6}$$

Separating in (1) the real from the imaginary part we get $\zeta = \rho e^{-i\theta}$, where

$$\left.\begin{aligned} \rho &= \frac{\sqrt{[1-(x_1^2+y_1^2)]^2+4y_1^2}}{(1+x_1)^2+y_1^2}; \quad \operatorname{tg}\theta = \frac{2y_1}{1-(x_1^2+y_1^2)}; \\ x_1 &= r_1^{\varkappa}\cos\varkappa\theta_1; \quad y_1 = -r_1^{\varkappa}\sin\varkappa\theta_1; \\ r_1 &= \frac{\sqrt{[1-(x^2+y^2)]^2+4y^2}}{(1+x)^2+y^2}; \quad \operatorname{tg}\theta_1 = \frac{2y}{1-(x^2+y^2)}; \quad z = x+iy. \end{aligned}\right\} \tag{7}$$

Formulae (7) afford the possibility of determining that point of the plane ζ which corresponds to a given point of the plane z.

The reverse case of finding in the plane z the point corresponding to a given point of the plane ζ is met by solving (1) with respect to z. Then after the separation of the real and imaginary parts we obtain

$$z = re^{i\varphi}$$

where

$$\left.\begin{aligned} r &= \frac{\sqrt{(1-\rho_2^2)^2+4\rho_2^2\sin^2\theta_2}}{1+2\rho_2\cos\theta_2+\rho_2^2}; \quad \operatorname{tg}\varphi = \frac{2\rho_2\sin\theta_2}{1-\rho_2^2}; \quad \rho_2 = \rho_1^{\frac{1}{\varkappa}}; \\ \theta_2 &= \frac{\theta_1}{\varkappa}; \quad \rho_1 = \frac{\sqrt{(1-\rho^2)^2+4\rho^2\sin^2\theta}}{1+2\rho\cos\theta+\rho^2}; \quad \operatorname{tg}\theta_1 = \frac{2\rho\sin\theta}{1-\rho^2}; \quad \zeta = \rho^{i\theta}. \end{aligned}\right\} \tag{8}$$

For practical calculations one must determine the values of ρ_n and $\varkappa$ corresponding to the oval contour of oil-bearing area L with semi-axes a and b. From (1) and (7) we get after some computations

$$\rho_n = \operatorname{th}\left(\frac{\varkappa}{2}\ln\frac{1+a}{1-a}\right) = \operatorname{tg}\left(\frac{\varkappa}{2}\operatorname{arc\,tg}\frac{2b}{1-b^2}\right). \quad (9)$$

ρ_n and $\varkappa$ are determined from these two equations. It may be recalled that a should here be larger than b and that the major axis of the biangle has been put at unity. The minor axis $OB = OD$, as may be easily shown, is determined from the equation $OB = \operatorname{tg}\frac{\gamma}{4}$. Let us point out that for a given ratio $\frac{b}{a}$ the value of a may be set arbitrarily, though of course observing the limitation that $a < 1$. In that way we shall obtain a variety of ovals, all with the same axes ratio. For the function (3) which is used to advantage when the feeding contour is near and linear (figure, *б*) we accordingly obtain

$$\frac{d\zeta}{dz} = \frac{1}{2}(1-\zeta^2), \quad (10)$$

$$\left|\frac{d\zeta}{dz}\right| = \frac{1}{2}\sqrt{[(1-\xi)^2+\eta^2][(1+\xi)^2+\eta^2]} \quad (11)$$

The separation of the real and imaginary parts in (3) gives

$$\xi = \frac{\operatorname{sh} x}{\operatorname{ch} x + \cos y}; \quad \eta = \frac{\sin y}{\operatorname{ch} x + \cos y}. \quad (12)$$

The reverse case of determining z from a known ζ is dealt with the most simply in the following way. As the solution of equations (12) with respect to x and y is a very cumbersome operation, it is better to represent (3) as $\zeta = \frac{e^z-1}{e^z+1}$; from this we have

$$e^z = \frac{1+\zeta}{1-\zeta}. \quad (13)$$

Putting $\zeta = \rho e^{i\theta}$, we get

$$x = \ln\frac{\sqrt{(1-\rho^2)^2+4\rho^2\sin^2\theta}}{1+2\rho\cos\theta+\rho^2}; \quad y = \operatorname{arctg}\frac{2\rho\sin\theta}{1-\rho^2}. \quad (14)$$

The further computations are made with the aid of the formulae for a circular bed. If a biangle formed by the intersection of two unequal circles be taken for the initial figure, the method described here will be found to solve the problem in the case of a crescent-like bed as well.

Received
1. VI. 1943.

REFERENCES

[1] I. A. Charny, C. R. Acad. Sci. URSS, XLII, No. 4 (1944).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

PHYSIQUE MATHÉMATIQUE

SUR QUELQUES CAS DE DISTINCTION ENTRE UN FOYER ET UN CENTRE

Par I. S. KOUKLESS

(Présenté par S. L. Soboleff, de l'Académie, le 24.X.1943)

Problème 1. Soient $f(x)$, $\varphi(y)$ et $\varphi_1(y)$ trois fonctions continues avec leurs dérivées et définies pour les valeurs des arguments aussi petites que l'on veut; d'ailleurs, chacune de ces fonctions sans être nécessairement analytique au voisinage de l'origine est analytique séparément pour les arguments positifs et pour les arguments négatifs, et l'on a $f_0(0)=0$; $f'(0)\neq 0$.

Supposons que la quatrième fonction $f_1(x)$ est définie seulement pour les valeurs de x non négatives (ou non positives).

Il faut déterminer $f_1(x)$ pour les valeurs négatifs (ou bien positives) de x de telle manière que l'origine soit un centre pour l'équation

$$\frac{dy}{dx}=\frac{f_0(x)\varphi_0(y)+f_1(x)\varphi_1(y)}{y}. \tag{1}$$

Il est possible de résoudre le problème posé, si pour $x\geqslant 0$ (ou bien pour $x\leqslant 0$) on a:

a) $\lim\limits_{x\to 0} f_1(x)\varphi_1(0)=0$,

b) $\lim\limits_{x\to 0}[f'(0)\varphi(0)+f_1'(x)\varphi_1(0)]<0$.

Si l'égalité

$$\frac{\varphi_1(y)}{\varphi_0(y)}=F(\rho) \tag{2}$$

(où $\rho=\int\limits_0^y \frac{t\,dt}{\varphi_0(t)}$, ou bien $\rho=\int\limits_0^y \frac{t\,dt}{\varphi_1(t)}$, et F est une fonction univoque quelconque) n'a pas lieu pour les petites valeurs de y, alors le prolongement indiqué de la fonction $f_1(x)$ est déterminé d'une manière unique par la formule

$$f_1(x)=\frac{d}{dx}\{u\{\lambda^{-1}[-\lambda(x)]\}\} \tag{2'}$$

[où $u(x)=\int\limits_0^x f(\alpha)\,d\alpha$; $\lambda(x)=\sqrt{u(x)}$; $\lambda^{-1}(x)$ est l'inverse de la fonction $\lambda(x)$]

et d'ailleurs $\lim\limits_{x\to 0}\frac{f_1(-x)}{f_1(x)}=-1$. Si l'egalité (2) a lieu pour les petites valeurs de x, l'origine sera un centre pour l'équation (2) quel que soit le prolongement de la fonction $f_1(x)$, pourvu que les conditions a) et b) précédentes subsistent pour $x\geqslant 0$ et aussi pour $x<0$.

On résout tout-à-fait de même le problème analogue: on suppose que les fonctions $f_0(x)$, $\varphi(y)$ et $f_1(x)$ $[\varphi_0(0) \neq 0]$ sont continues ainsi que leurs dérivées, et la fonction $\varphi_1(y)$ n'est définie que pour les valeurs de y non négatives (ou bien non positives) et il faut la prolonger pour les valeurs négatives (positives) de y de telle manière que l'origine soit un centre.

Dans ce cas la solution du problème est possible, si pour $y \geqslant 0$ (pour $y \leqslant 0$) on a:

c) $\lim\limits_{y \to 0} [f(0)\varphi(0) + f_1(0)\varphi(y)] = 0;$

d) $\lim\limits_{y \to 0} [f'(0)\varphi(0) + f_1(0)\varphi(y)] < 0;$

e) $\lim\limits_{y \to 0} \left\{ f_1(0)\varphi'(y) - 2\sqrt{f_0(0)\overline{\varphi}(0) + f_1(0)\overline{\varphi}(y)} \right\} < 0.$

Si l'égalité

$$\frac{f_1(x)}{f_0(x)} = F(u), \tag{3}$$

où F est une fonction univoque quelconque et $u = \int\limits_0^x f_0(\alpha)\, d\alpha$, ou bien $u = \int\limits_0^x f_1(\alpha)\, d\alpha$, n'a pas lieu, le prolongement cherché de la fonction $\varphi(y)$ est déterminé d'une manière unique par la formule:

$$\varphi_1(y) = \varphi_0(y) \frac{\varphi_1\{\lambda^{-1}[-\lambda(y)]\}}{\varphi\{\lambda^{-1}[-\lambda(y)]\}} \tag{3'}$$

$\left[\text{où } \lambda(y) = \sqrt{\int\limits_0^y \frac{t\,dt}{\varphi_0(t)}},\ \lambda^{-1}(y) \text{ est l'inverse de } \lambda(y)\right].$

Si l'égalité (3) a lieu pour les petites valeurs de x, alors l'origine est un centre pour l'équation (1) quelque que soit le prolongement de $\varphi(y)$, pourvu que les conditions c), d) et e) aient lieu.

Exemple 1.

$$\frac{dy}{dx} = -\frac{x(1+3ax+2a^2x^2)(1+by)^3 + f(x)\varphi(y)}{y}, \tag{4}$$

où $f(x)$ et $\varphi(y)$ sont définies et analytiques pour les valeurs non positives de leurs arguments. Il faut les prolonger pour les valeurs négatives des arguments de telle manière que l'origine soit un centre pour l'équation (4). On a pour $x < 0$

$$f(x) = \frac{d}{dx}\left\{\psi\left[\frac{1}{2a}\left(\sqrt{1-4ax-4a^2x^2}-1\right)\right]\right\},$$

où $\psi(x) = \int\limits_0^x f(t)\, dt$, et la fonction $\varphi(y)$ est prolongée arbitrairement, ou bien pour $y < 0$

$$\varphi(y) = (1+2by)^3 \varphi\left[-\frac{y}{1+2by}\right],$$

et $f(x)$ est prolongée arbitrairement.

Problème 2. La fonction $F(x, y)$ dans l'équation différentielle (1)

$$\frac{dy}{dx} = \frac{F(x, y)}{y} \tag{1'}$$

est de la forme $F = \omega_0(x) + y\omega_1(x) + y^2\omega_2(x)$, où deux quelconques des trois fonctions ω_0, ω_1 et ω_2 sont arbitrairement données. Il faut déterminer la troisième fonction de telle manière que l'origine soit un centre pour l'équation (1) s'il appartient au second groupe des points singuliers (c'est-à-dire s'il est

un foyer ou bien un centre). La troisième fonction se trouve de la relation: $\omega_2 = f(x)$; $\omega_1 = p[f(x)\varphi(x) - \varphi'(x)]$; $\omega_0 = q[f(x)\varphi(x) - \varphi'(x)]\varphi(x)$, où f et φ sont des fonctions arbitraires, et p et q — des constantes arbitraires.

Problème 3. La fonction $F(x, y)$ de l'équation différentielle (1') est de la forme $F(x, y) = \omega_0(x) + y\omega_1(x) + y^2\omega_2(x) + y^3\omega_3(x)$, où trois quelconques des quatre fonctions ω_0, ω_1, ω_2 et ω_3 sont arbitrairement données. Déterminons la quatrième fonction de telle manière que l'origine soit un centre. La quatrième fonction se trouve des relations:

$$\omega_0 = 2\varphi(x)[f_1(x)\varphi(x) + 4f_2(x)\varphi^2(x) - \varphi'(x)];$$
$$\omega_1 = 3[f_1(x)\varphi(x) + 4f_2(x)\varphi^2(x) - \varphi'(x)];$$
$$\omega_2 = f_1(x) + 6\varphi(x)f_2(x);$$
$$\omega_3 = f_2(x)$$

(où f_1, f_2 et φ sont des fonctions arbitraires). Pour l'équation (1') l'origine sera un centre s'il appartient au second groupe.

La résolution des problèmes 2 et 3 est basée sur l'application du théorème 1 exposé dans la Note (1): remarquons d'ailleurs que le problème 3 ne peut être généralisé en ce sens que, si au lieu de 4 fonctions ω_0, ω_1, ω_2 et ω_3 nous avions un plus grand nombre de fonctions, nous n'aurions pu donner arbitrairement toutes les fonctions sauf une seule, sans faire tomber les conditions pour un centre. Considérons maintenant l'équation différentielle

$$\frac{dy}{dx} = -\frac{F(x, y)}{y} + \varphi(x^2) \qquad (5)$$

où F et φ sont analytiques au voisinage de l'origine, et d'ailleurs

$$F(0, 0) = 0;\ \frac{\partial F(0, 0)}{\partial x} > 0. \qquad (6)$$

Posons le problème suivant:

Problème 4. Existe-t-il quelle que soit la fonction analytique $F(x, y)$ vérifiant les conditions (6) une certaine fonction $\varphi(x^2)$, pour laquelle l'origine soit un centre pour l'équation (6)? Cette fonction $\varphi(x^2)$ existe toujours, elle est analytique et déterminée d'une manière unique par les conditions successives du centre. La résolution de ce problème est basée sur l'application des conditions pour un centre exposées dans la Note (1).

Remarque. Il est connu que le critère le plus simple pour l'existence d'un centre est la symétrie des caractéristiques par rapport aux axes des coordonnées. Nous avons démontré que *la symétrie des caractéristiques de l'équation différentielle* (1') *par rapport à des axes passant par l'origine, mais ne coïncidant pas avec les axes des coordonnées, est impossible, si* $F(x, y)$ *est un polynôme de degré supérieur à* 1.

Etudions la question, comment distinguer un foyer d'un centre à l'origine des coordonnées pour l'équation différentielle (1'), où $F(x, y)$ est un polynôme du 5-ième degré

$$F(x, y) = -x + c_0x^2 + d_0x^3 + e_0x^4 + f_0x^5 + y(b_1x + c_1x^2 + d_1x^3 + e_1x^4) +$$
$$+ y^2(a_2 + b_2x + c_2x^2 + d_2x^3) + y^3(a_3 + b_3x + c_3x^2) + y^4(a_4 + b_4x) + a_5y^5.$$

Problème 5. Trouver toutes les relations possibles entre les 18 coefficients: a_2, a_3, a_4, a_5, b_1, b_2, b_3, b_4, c_0, c_1, c_2, c_3, d_0, d_1, d_2, e_0, e_1 et f_0, qui doivent avoir lieu dans le cas d'un centre.

Les neuf premières conditions d'un centre ne sont vérifiées que dans les neuf cas suivants:

1-er cas: $a_5 = \frac{1}{2}b_1a_4$; $a_4 = 8a_3b_1$; $b_4 = 8a_3\lambda$; $b_2b_1 = 2a_3\lambda$; $c_2b_1^2 = a_3\lambda^2$; $\tau = 2b_1^3$;

$$\alpha = \beta = \gamma = \delta = \varepsilon = \eta = \zeta = 0 \qquad (7_1)$$

et ou bien $b_1 \neq 0$, ou bien $\varkappa = \mu = \omega = 0$.

2-ième cas: $a_5 = -\frac{1}{25} a_4 b_1$; $a_4 = -\frac{1}{10} a_3 b_1$; $b_4 = -\frac{1}{10} a_3\lambda$; $b_3 b_1 = 2a_3\lambda$; $c_3 b_1^2 = a_3\lambda^2$; $\tau = -\frac{4}{25} b_1^3$; $\alpha = \beta = \gamma = \delta = \varepsilon = \eta = \zeta = 0$ (7_2)

et ou bien $b_1 \neq 0$, ou bien $\varkappa = \mu = \omega = 0$.

3-ième cas: $a_5 = 0$; $a_4 = -\frac{1}{16} a_3 b_1$; $b_4 = \frac{1}{16}(a_3\lambda - b_3 b_1)$; $c_3 b_1^2 = -\lambda(a_3\lambda - b_3 b_1)$; $\tau = -\frac{3}{16} b_1^3$; $\alpha = \beta = \gamma = \delta = \varepsilon = \eta = \zeta = 0$ (7_3)

et ou bien $b_1 \neq 0$, ou bien $\varkappa = \mu = \omega = 0$.

4-ième cas: $a_5 = a_4 = b_4 = 0$; $\tau = -\frac{2}{9} b_1^3$; $\alpha = \beta = \gamma = \delta = \varepsilon = \eta = \zeta = 0$ (7_4)

et ou bien $b_1 \neq 0$, ou bien $\varkappa = \mu = \omega = 0$.

5-ième cas: $a_5 = a_4 = a_3 = b_4 = b_3 = c_3 = 0$; $\alpha = \beta = \gamma = \delta = \varepsilon = \eta = \zeta = 0$ (7_5)

et ou bien $b_1 \neq 0$, ou bien $\varkappa = \mu = \omega = 0$.

6-ième cas: $a_5 = a_4 = a_3 = b_4 = b_3 = c_3 = c_2 = e_1 = d_2 = 0$; $\delta + (a_2 b_1 + 2c_1)\alpha = (a_2 + c_0)\alpha + \beta = \varepsilon + (b_2 b_1 + 2d_1)\alpha = d_1\alpha + b_1\gamma = \eta = \zeta = 0$ (7_6)

et ou bien $b_1 \neq 0$, ou bien $\varkappa = \mu = \omega = 0$.

7-ième cas: $a_5 = a_4 = a_3 = a_2 = d_1 = 0$; $3\beta + 5c_0\alpha = c_0^2\alpha + c_0\beta + \gamma = \delta = \varepsilon = \eta = \zeta = 0$ (7_7)

et ou bien $b_1(b_2 b_1 + 3b_3) \neq 0$, ou bien $b_3 c_0 + c_3 = b_2 c_0 + c_2 = 3f_0 - 2c_0 e_0 = 3e_0 + 5c_0 d_0 = e_1 = d_2 = 0$.

8-ième cas: $a_5 = a_4 = a_3 = a_2 = c_3 = c_2 = c_1 = c_0 = e_1 = e_0 = 0$. (7_8)

9-ième cas: $a_5 = a_3 = b_3 = c_3 = d_1 = e_1 = c_1 = b_1 = 0$. (7_9)

Dans les égalités (7_{1-7}) nous avons posé:

$$\lambda = a_2 b_3 + 3a_3;\quad \tau = 3b_3 - 2\lambda c_0 + 2d_0 b_1 + 2d_1 - \lambda a_2 + b_2 b_1;$$
$$\alpha = (d_0 b_1 + d_1) b_1 + c_1\lambda;\quad \beta = (e_0 b_1 + e_1) b_1 + d_1\lambda;\quad \gamma = f_0 b_1^2 + e_1\lambda;$$
$$\delta = (3a_3\lambda + 3b_3 b_1 + \lambda^2 + b_2 b_1^2) c_1 - 3a_3\lambda^2 - 6b_3 b_1\lambda - b_2 b_1^2\lambda - 3c_3 b_1^2 - c_2 b_1^3;$$
$$\varepsilon = (3a_3\lambda + 3b_3 b_1 + \lambda^2 + b_2 b_1^2) d_1 - b_1^2(c_2\lambda + d_2 b_1) - 3\lambda(c_3 b_1 + b_3\lambda);$$
$$\eta = (3a_3\lambda + 3b_3 b_1 + \lambda^2 + b_2 b_1^2) e_1 - \lambda(d_2 b_1^2 + 3c_3\lambda);$$
$$\zeta = c_0 b_1 + c_1 + \lambda;$$
$$\varkappa = (d_1 + d_0 b_1) d_1 - (e_1 + e_0 b_1) c_1 - \frac{5}{3} c_0^2\alpha;$$
$$\mu = (e_1 + e_0 b_1) e_1 - d_1 f_0 b_1 + \alpha[f_0 + a_2 c_0 (a_2 + c_0)^2] + \beta a_2 c_0 (a_2 + c_0) + \gamma[a_2 (a_2 + c_0) - d_0];$$
$$\omega = b_1 (a_2 + c_0)(8a_2^2 - a_2 c_0 - 5c_0^2 + 7b_1^2) + 24a_2^2 a_3 + 5a_2^2 c_1 + 6a_2 a_3 c_0 - 6a_2 c_1 c_0 - 7a_2 b_1 d_0 - 2a_2 b_1 b_2 + 23b_1^2 a_3 + 7b_1^2 c_1 - b_1 b_2 c_0 - 8b_1 c_0 d_0 - 5c_0^2 c_1 - 7a_2 d_1 + 5a_2 b_1 + 3a_3 b_2 - 3c_1 d_0 - 3b_1 e_0 - 5c_0 d_1 - b_1 c_2 - 9a_2 b_2 - 3b_3 c_0 - 15a_5 - 3c_3 - 3e_1.$$

Les cas (7_8) et (7_9) d'un centre sont bien évidents. Dans les autres cas l'existence d'un centre peut être démontrée en s'appuyant sur le théorème de la Note [2].

Manuscrit reçu
le 20. XI. 1943.

LITTÉRATURE CITÉE

[1] I. S. Koukless, C. R. Acad. Sci. URSS, XIX, No. 6—7 (1938). [2] I. S. Koukless, C. R. Acad. Sci. URSS, XLII, No. 4 (1944).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

CHEMISTRY

CONTRIBUTION TO THE PROBLEM OF A WATER-SOLUBLE CAMPHOR, «CAMPHOR Vi»

By W. A. ISMAILSKI

(Communicated by A. E. Poray-Koshitz, Member of the Academy, 25.XI.1943)

Having a number of drawbacks, the oil solution of camphor does not permit to profit fully of its activity.

At the suggestion of the Red Army Sanitary Institute the author undertook work aiming to obtain a water-soluble preparation; he was successful in finding such conditions for a durable stabilization of camphor solution as would eliminate any danger of embolia during intraveinous administration. It has been found possible to obtain a preparation of camphor* instead of its derivatives or substitutes.

While studying the effect of various substances upon the solubility of camphor the following was found: 1) even at lowest concentrations ethanol exhibits a remarkable ability to increase the solubility of camphor in aqueous solutions of sodium salicylate or any substitutes for the latter; 2) with a definite ratio between alcohol and sodium salicylate water solutions of camphor can be prepared which will be stable at any concentration (see table, Nos. 1, 2, 3).

Nos.	Preparation	Camphor		Alcohol 96°		Sodium salicylate		Sodium benzoate		Resistance to water
		g/cm³	%	g/cm³	%	g/cm³	%	g/cm³	%	
1	Vi-17	0.02	2.0	0.30	30	0.25	25	—	—	Stable*
2	Vi-18	0.015	1.5	0.24	24	0.25	25	—	—	»
3	Vi-32 (33)	0.01	1.0	0.20	20	0.25	25	—	—	»
4	—	0.01	1.0	0.05	5	0.25	25	—	—	Unstable
5	—	0.01	1.0	0.20	20	0.15	15	—	—	»
6	—	0.01	1.0	0	0	0.50	50	—	—	»
7	—	0.015	1.5	0.25	25	0.126	12.6	0.126	12.6	Not quite stable
8	Vi-34	0.015	1.5	0.25	25	0.125	12.6	0.20	20	Stable

* In the given case a small opalescence after standing.

No stable camphor solutions can be obtained by using alcohol or sodium salicylate alone: in both cases a precipitate is formed upon addition of water. No stable solution of due concentration can be obtained even in a 50 per cent solution of sodium salicylate (50 parts of the solution to 1 part of camphor) without adding alcohol. When combined with sodium salicylate, the ratio alcohol: camphor 5 : 1, 10 : 1 (5—10 per cent) is still not high enough (see table, No. 4). Fully stable solutions can be preparated at a ratio 20 : 1 (20 per cent of ethyl alcohol 96°)

* First reported at the Red Army Sanitary Institute on May 7th, 1942, and at the Chemical department of the All-Union Institute for Experimental Medicine.

An addition of alcohol makes it possible to reduce the amount of salicylate to 20—25 parts per one part of camphor, which facilitates greatly the procedure: aqueous salicylate solution is poured into the alcohol solution of camphor, and water is added until necessary volume is reached.

The difficulties we encountered consisted in that the solutions containing sodium salicylate were found to darken when stored*. We succeeded in eliminating this defect in ampulae by using water freed of oxygen by boiling and slightly saturating it with CO_2, as well as by sealing them up under CO_2. The solutions were sterilized by pasteurizing them at 60° C**. The preparation does not congeal, becoming thick, which is important under field conditions.

The preparation is being manufactured in ampulae of 1, 2 and 3 cm³ at the Tomsk pharmaceutic factory No. 4, under the name of «Camphor Vi» (*Camphora aquasoluta* Vi), with addition of the typical number, e. g. «Camphor Vi-32» (1 per cent), «Camphor Vi-17» (2 per cent). In most details we have investigated the 1 per cent preparation No. 32 which has also been tested as No. Vi-33 (³) (see table, No. 3). Preparations Vi-17 (2 per cent) and Vi-18 (1.5 per cent) (see table, Nos. 1, 2) deserve special attention for subcutaneous injections because of their increased camphor content; their clinical testing is, however, still in progress.

The effect of resorcine is analogous to that of salicylate. With the aid of sodium benzoate deprived of phenolic hydroxyl, one succeeds in preparing stable solutions only if combined with sodium salicylate (see table, Nos. 7, 8). Inefficient are: glycerine, glucose, Na-salt of phtalic, β-naphtasulphonic, and camphosulphonic acids.

It may be assumed that camphor is maintained in solution through the formation of associative complexes ***, say, of the H-phenolic hydroxyl activized with *o*-carboxyl (¹).

$$\text{I. } [(R > \dot{C} = O \ldots HO - C_6H_4 - COO) \cdot n\,C_3H_5OH]^-Na^+.$$

The Na-salicylate cannot be replaced either by salts of the *p*-oxybenzoate acid, or by *p*- and *o*-phenolic sulphoacids (experiments by N. Volkenau).

Pharmacological testing was started at the Red Army Sanitary Institute by B. S. Senturin and carried out later on by Prof. N. W. Wershinin and E. M. Dumenova at the Pharmacological Laboratory of the Tomsk Medical Institute. As material dogs and rabbits were used, in which collapse and shock were induced experimentally (³).

When injected subcutaneously, the respiratory function was restored in the case of acute collapse within 1—3 minutes. When introduced intravenously, the effect was manifest after 50—60 seconds. With arterial tension reduced by alcohol down to 60 mm, the injection of 1 cm³ into the vein gradually restored a normal tension within 30 minutes (see figure).

In the case of a very grave shock followed by a drop of arterial tension to 0—20 mm, an one-time injection into the vein of 1 cm³ of the preparation failed to give stable results: there was but a slight rise of arterial tension up to 20 mm, and death ensued after an hour and a half.

When introduced into the vein by the drop-method at a dilution $1 : 10^5$—$1 : 5 \times 10^5$, the preparation gave a pronounced tonifying effect: total removal of the shock, raising of the arterial tension up to the normal (³).

«The effect of subcutaneous injections does much exceed that of oil-solutions as to rapidity. The fact that subcutaneous and intravenous injections of Vi-32

---

* A negligible concentration of OH' (traces of Na, hydrolysis of benzoate) enhances the darkening, both when exposed to air and in ampulae.

** In this work we were helped by senior laboratory assistant I. M. Karpenko.

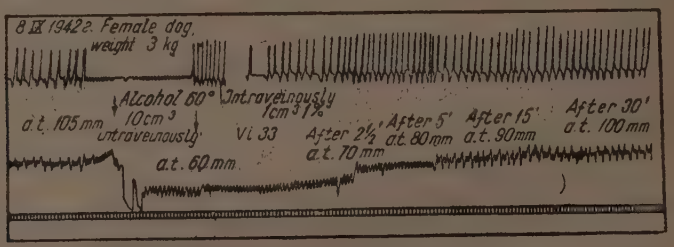
*** A solvent of a different type has been found in the Na-salt acid ester of *l*-borneol and phtalic acid (see below). The effect of this salt is associated by us with its emulgent and foam-forming ability. The salt of camphocarbonic acid is likely to produce a similar effect. Tests along this line are in progress.

do not differ much as to the rapidity of their effect, speaks in favour of the former as being both simpler and safer» (3)*.

Clinical tests of the preparation «Camphor Vi-32» were being performed at the clinique of infectious diseases of the Tomsk Medical Institute by Prof. I. A. Minkevich and V. J. Kindsvater, on patients exhibiting phenomena of cardio-vascular collapse as a complication of typhoid fever (in one case there was toxic infection). The experiments are being continued now by T. S. Kuznetzova and J. J. Sokolovskaya.

Subcutaneous injection of 1 cm^3 of a 1 per cent preparation resulted after 10—15 minutes in a rise of blood pressure by 8—13 mm. By the capillaroscopic method a better state of peripheral blood circulation could be observed. The preparation was administered per 1 cm^3 thrice a day, and was withdrawn in a number of patients as soon as after three days, because of a stable amelioration of their cardio-vascular system .

The preparation provoked no local phenomena, except for a small inflammation around the punctures (in 25 per cent of the cases). No infiltrations usually attending injections of oil solutions of camphor were observed. A few patients complained of painfullness (burning that ceased some 5—6 minutes after the injection). Unlike the subcutaneous injection, the intramuscular one is rather painful.



Curve of record of respiration and blood pressure (Prof. N. W. Wershinin and assistant professor E. M. Dumenova)

Intraveinous injection was followed by a rapid positive effect: the blood pressure rose directly by 15 mm, and by 25 mm after one hour. A rapid improvement of the capillary circulation could be observed.

According to a testimonial given by Prof. Minkevich, «the data obtained may be considered as fully satisfying the requirements of the clinique», «the preparation is highly valuable and should be subjected to tests on a wide clinical scale». The preparation is likely to become a powerful means for combating collapse attending infectious diseases. The dosage of the drug is to be worked out more accurately.

Prof. N. W. Wershinin writes in his conclusions: «The preparation Camphor-Vi may, on the ground of laboratory investigations and clinical observations available, be recommended for extensive therapeutic application».

The preparation introduced by the author can entirely replace those imported from abroad: hexeton, camphogen (Germany), vita-camphora (Japan), etc. with which it compares favourably. Its advantage over hexeton (widely used in the German army) consists in that its manufacturing is based upon the camphor proper instead of synthetic ketone. It is superior to camphogen because instead of the expensive and therapeutically worthless acet-diethyl-amide as an additional substance serving to stabilize the solution of camphor in water, it contains, aside from sodium salicylate, also ethyl alcohol which has recently been recognized as a tonic means to combate shock when introduced intraveinously.

Thus, the problem our medecine was facing for a long time, viz. the production of an aqueous camphor solution for intraveinous and subcutaneous injections,

* According to recent observations, our preparation is likely to be useful as a cardio-vascular stimulator when administered *per os* as well, by virtue of ist rapid absorbability.

has been solved in a new way. For the manufacturing of the preparation our native levorotatory «Siberian» camphor is being used.

As for the sodium salicylate, it was successfully used in the preparations hexeton and camphogen. Like alcohol, it does not prevent, but rather strengthens the tonic effect of the camphor. Mordrakowski and Sikorski [1] attribute the effect of hexeton to sodium salicylate and not to the synthetic ketone. It should be added that the former is applied at high doses for the treatment of endocarditis accompanying rheumatic diseases (mal de Bouillot).

Our water-soluble preparation has the following advantages over the oil solution: 1) Camphor-Vi can be applied both subcutaneously and intraveinously. 2) In either case the preparation is more efficacious, owing to a more rapid supply of the camphor into the blood. 3) It offers a means to rapidly release the patient from a menacing state of its respiratory and cardio-vascular activity in the case of collapse. Respiration is restored within 1—2 minutes, which never could be achieved by means of oil solution. 4) When injected subcutaneously, the use of the preparation is attended by no local complications that are of frequent occurrence in case oil solutions are applied (infiltrations, abscesses, phlegmons), because of the slow resorption and irritation of tissues by camphor.* 5) The dose of camphor can be reduced several times.

We have also worked on the obtaining of a derivative of camphor, or of compounds that might serve as its substitutes, being at the same time soluble in water. Ammonia salts of *l*-camphosulphonic acid** (L. I. Lewitan) and of *l*-camphocarbonic acid (P. Popov)*** have been synthesized from levorotatory camphor. From *l*-borneol esters of the type $C_{10}H_{14}O—R—COOH$ and $C_{10}H_{14}O—CO—R—COOH$ with phtalic and succinic acid have been obtained (A. I. Kravchenko). Borneol was expected to produce an effect similar to that of camphor. E. M. Dumenova carried out preliminary experiments with dogs in a state of collapse induced by alcohol. She applied 10 per cent solutions of NH_4 salt of the *l*-camphosulphonic acid (Vi-22), Na-salts of the acid ester of *l*-borneol and phtalic acid (Vi-41). To judge by the shape of the curve of respiration and blood pressure, their effect was rather close to that of camphor in the case of collapse. It is a matter for regret that the preparation Vi-41 is not stable enough for storing. We shall return to the subject in more detail after the observations reported above will have been checked up.

Aqueous solutions of camphor proper favourably compare with the synthetic substitutes, because the latter will always differ in some respect from the thoroughly studied camphor.

On the basis of sodium salicylate and camphor with alcohol we have moreover suggested an anti-rheumatic preparation to which we gave the name of «Camphosal». The content of camphor in it is correspondingly reduced: an ampula of 8 cm^3 contains 2.0 g of sodium salicylate, 1.2 g of 96° alcohol, and 0.01 g of camphor. The preparation is being tested by Prof. S. A. Adamov in the Propaedeutic therapeutical clinique of the Tomsk Medical Institute.

Thanks are due to Prof. N. W. Wershinin, Prof. S. A. Adamov, Prof. I. A. Minkevich, assistant professor E. M. Dumenova and assistant V. J. Kindsvater who were so kind as to test our preparations.

V. V. Kuybyshev State University.
Tomsk.

Received
25. XI. 1943.

REFERENCES

[1] Mordrakowski, Sikorski, C. R. Soc. Biol., **93**, 950, 953 (1925). [2] Reychler, Bull. (3), **19**, 120 (1898). [3] Е. М. Думенова, Сб. работ Санит. службы СИБВО, 2, 375 (1943). [4] Н. С. Ведров, Вестник венерологии и дерматологии, № 2, 40 (1938).

* Subsequent tissue degeneration and reduction of the resorptive ability, as a consequence of oil bismuth preparations and of oil injections in general has been reported by Vedrov (4).

** Sulphurating with 12 per cent oleum after Reychler (2) in acetic anhydride. Experiments on substituting oleum with acetic acid for acetic anhydride yielded no good results.

*** This acid, as well as the *l*-camphosulphonic one, were studied for lack of literary data as to derivatives of *l*-camphor, and because of the highly conflicting data as to the physiological effect of the *d*-camphor.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLI, № 5

GEOCHEMISTRY

ON THE RUBIDIUM CONTENT OF SEA WATER

By T. F. BOROVICK-ROMANOVA

(Communicated by V. G. Chlopin, Member of the Academy, 28.VIII.1943)

This note gives a brief account of the results obtained by the author in the course of her investigation of the distribution of rubidium in the biosphere (1).

Data on rubidium content of sea water are scarce and not all of them reliable enough.

In 1862 Grandeau (2) studied the water of the Atlantic Ocean and of the Dead Sea, but found no rubidium.

In 1870 Sonstadt (3) at first found both rubidium and caesium in sea water, but afterwards renounced to his conclusions.

In 1878 Schmidt (4) investigated the water of different seas, and among other elements determined the presence of rubidium. He found that the rubidium content of sea water is on the average 1.24×10^{-3} per cent. This value later on was found to be overestimated, which should be referred to the inaccuracy of Schmidt's method.

In 1932 Burkser (5) found the water of the Black Sea to contain 3.2×10^{-5} per cent Rb, and that of the Azov Sea, 2.0×10^{-5} per cent Rb.

In 1933 Goldschmidt determined the rubidium content of the water of the North Sea (2.0×10^{-5} per cent).

In 1940 Burkser and Kovaleva (6) found the rubidium content of the water of the Mediterranean to be 3.4×10^{-5} per cent, of that of the English channel, 2.4×10^{-5} per cent, and that of the Black Sea (Odessa bay), 4.5×10^{-5} per cent.

W. I. Vernadsky (7) more than once suggested that the problem as to the rubidium content in sea water could not be considered as definitely settled, and that it required further investigation.

The author has determined the content of rubidium of the water of the Barents Sea, Kara Sea, Sea of Japan, Longa Strait, Greek Archipelago, two samples from the Black Sea (taken near Gagry and Eupatoria). Two samples of water from the Black Sea were investigated, taken at the same place, but at different depths—200 and 1500 meters, as well as silty waters of the Barents Sea and of the Sea of Okhotsk.

Subjected to study were also the waters of some inland seas and salt lakes (Caspian Sea, Aral Sea, lake Inder, and Mainak estuary).

The determination of the rubidium content in sea water was made by the method of spectrum analysis. As the source of spectrum excitation, a burner with an acetone vapour flame was made use of (8). In order to introduce the sample into the flame, strips of an ashless filter were soaked with concentrated sea water, dried, and brought into the flame with the aid of a platinum wire. The photographs of the spectrum were taken with a Hilger glass spectrograph, on plates of the Sci. Res. Cinema and Photo-Institute, infra-chrome 810. The concentrations of rubidium

were estimated by comparing the absolute intensities of Rb lines at 7800.23 Å and 7947.60 Å in the specimens tested to those in standards. The method permits to determine the presence of 5×10^{-5} per cent rubidium in solution. The mean arithmetical error of the measurement is ± 10—25 per cent. The results obtained are given in Tables 1 and 2.

Table 1

Water basin	Place and time of sampling	Rb content in % (individual determinations)	Average Rb content in %	Rb/K ratio
Barents Sea	—	2.0×10^{-5} 2.0×10^{-5} 2.5×10^{-5}	2.2×10^{-5}	0.00058
» «	35 miles north off the shore of Dalniye Zelentzy bay	1.6×10^{-5} 1.7×10^{-5} 2.2×10^{-5}	1.8×10^{-5}	0.00047
Kara Sea	—	2.0×10^{-5}	2.0×10^{-5}	0.00053
Sea of Japan	Near Vladivostok	2.0×10^{-5} 2.2×10^{-5}	2.1×10^{-5}	0.00055
Greek Archipelago	—	2.0×10^{-5} 1.8×10^{-5} 2.0×10^{-5}	1.9×10^{-5}	0.00050
Longa Strait	—	1.8×10^{-5}	1.8×10^{-5}	0.00047
Black Sea	Eupatoria, 10 km off shore, 1937	9.0×10^{-6} 9.0×10^{-6}	9.0×10^{-6}	0.00043
» »	Gagry, 1 km off shore, 1937	1.0×10^{-5} 1.0×10^{-5}	1.0×10^{-5}	0.00048
» »	Depth of 200 m	9.4×10^{-6} 9.1×10^{-6} 9.3×10^{-6}	9.2×10^{-6}	—
» »	Depth of 1500 m	1.2×10^{-5} 1.0×10^{-5} 1.2×10^{-5}	1.1×10^{-5}	—
Silty water of the Barents Sea	Yarnyshnaya bay	2.0×10^{-5} 2.0×10^{-5} 2.0×10^{-5}	2.0×10^{-5}	—
Silty water of the Sea of Okhotsk	Sad-Gorod	1.5×10^{-5} 1.7×10^{-5} 2.1×10^{-5}	1.8×10^{-5}	←

Table 2

Inland Seas and Salt Lakes

Water basin	Rb content in %	Rb/K ratio
Caspian Sea	$< 3 \times 10^{-6}$*	< 0.00034
Aral Sea	1.5×10^{-6}	0.00019
Lake Inder	5.7×10^{-4}	0.00053
Mainak estuary	9.3×10^{-5}	0.00047

The results obtained permit to consider that the rubidium content of the water of open seas is similar for all the seas investigated, being on the average 2×10^{-5} per cent. The water of the Black Sea contains less rubidium than that of the other seas investigated (9.4×10^{-6} per cent).

The rubidium content of the samples of water from the Black Sea taken at the same place, but at different depths (200 and 1500 m) practically does not vary.

* In the Caspian Sea water no rubidium was discovered. As the method permitted to find in the dry residue 2×10^{-4} per cent Rb, it may be considered that the Rb content of the Caspian Sea water was $< 3 \times 10^{-6}$ per cent.

The silty waters of the Barents Sea and the Sea of Okhotsk approach sea water as to their rubidium content.

As to the Rb/K ratio in sea water, it was found to be a nearly constant value for all the seas investigated and to be equal on the average to 0.0005. For inland seas, however, the Rb/K ratio is lower.

In conclusion, the author wishes to acknowledge the valuable suggestions and assistance on the part of W. I. Vernadsky, Member of the Academy, Prof. A. P. Vinogradov, and Prof. S. A. Borovick.

W. I. Vernadsky Laboratory of Geochemical Problems.
Academy of Sciences of the USSR.

Received
28. VIII. 1943.

REFERENCES

[1] Т. Ф. Боровик-Романова. Рубидий в биосфере, диссертация, 1942. [2] Grandeau, Annales Chim. et Phys., **67**, 204 (1863). [3] Sonstadt. Chem. News, **22**, 25—44 (1870); Bull. de la Soc. Chim., **2**, 14, 125 (1870). [4] K. Schmidt, Bull. Acad. Pétersb., **24**, 231 (1878). [5] Е. С. Бурксер, Н. В. Комар, С. Г. Рублев и Р. И. Устиловская, Труды Биогеохимич. лаборатории, **2**, 65 (1932). [6] E. S. Burkser and K. N. Kovaleva, Доповіді Акад. Наук УРСР, No. 5, 31 (1940). [7] W. I. Vernadsky. Mineral. und Petrograph. Mitt., **44**, 2—3, 183 (1933); Биогеохимич. очерки, 45, изд. АН СССР, 1940. [8] T. F. Borovick-Romanova, C. R. Acad. Sci. USSR, XXI, No. 7, 334 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

GEOCHEMISTRY

ON THE GEOCHEMISTRY OF THE PETROLIFEROUS DEPOSITS OF THE BUGURUSLAN REGION AND THE OUTLOOK FOR SEARCH IN THE SECOND BUGURUSLAN

By G. I. THEODOROVICH

(Communicated by V. G. Chlopin, Member of the Academy, 28.VIII.1943)

I. Sulphur as an evidence for oil prospecting in the Second Baku.

The author has recently become aware of the fact that in the carbonate series of the spirifer deposits of the Buguruslan region native sulphur forms a semi-halo, surrounding from the north-west the oil-bearing zone in the plane of bedding. It is mainly produced by a reduction of the sulphate ion of aqueous solutions to hydrogen sulphide under the influence of the reducing conditions prevailing at the periphery of the gas-oil deposit (1), bacterial agency probably contributing to this process. The greater part of the hydrogen sulphide formed must evidently be moving, in general, along the path of edge waters, while the lesser part, moving towards the water stream carrying oxygen, would cause the appearance of native sulphur segregations in the zone where the oxidizing and reducing media tend naturally to dislodge each other. Thus, it may be presumed that the bulk of the hydrogen sulphide of the oil deposits and gas caps of the oil fields of the Second Baku are of secondary origin, being related to the presence in the roof section or in the petroliferous deposits proper of Ca sulphates and, hence, to the presence of considerable amounts of the sulphate ion in the waters of these oil fields. As it has been established by the author, the sulphur originates here under conditions of a disturbance — be it even a temporary one — of the roof of the oil deposit (2) or a lateral access to it (under the cover) of oxygen carrying edge waters of a surface origin (1).

The native sulphur formed at the boundary between the reducing and the oxidizing media is stable not only in this zone, but partly also in the reducing medium, if the latter subsequently encroaches upon the sulphur-bearing zone.

Thus, the importance of native sulphur as an evidence in search and prospecting for oil comes to the for (2) for the Ural-Volga petroliferous region (of the Second Baku) in particular, and in general for the oil provinces of a similar type (from the standpoint of a marked content of the sulphate ion in waters).

II. Semi-haloes of secondary minerals in the Buguruslan region.

The author has shown in a previous paper (1) that the sulphur segregations in the Buguruslan region are often located above the segregations of a white distinctly granular calcite, occurring in the caverns and pores of the carbonate series of the spirifer substage and directly adjoining the enclosing rock. Calcite of this type has been encountered in most of the Amanak wells, in some southern peripheral holes

of Pokhvistnevo, the transitional zone from West Kalinovka to Pokhvistnevo, West and East Kalinovka, as well as in the northern part of the Bolshoy Kinel uplift.

Thus, in the deposits of the carbonate series of the spirifer substage there is observed a semi-halo of rocks secondarily enriched with distinctly granular calcite, to a certain extent similar to the sulphur-bearing semi-halo. In analogous points of the periphery of the Buguruslan gas-oil field, there are observed phenomena of impregnation with gypsum of rocks, manifested chiefly as the appearance of secondary distinctly granular gypsum cement of the intergrowth type.

III. Secondary distinctly granular calcite in the Buguruslan region.

The distinctly granular calcite in the dolomite beds of the spirifer substage of the Buguruslan region is represented by several types:

1) Calcite filling or half-filling caverns and pores along the western periphery of gas-oil accumulations, apparently secondary, like the sulphur which it often underlays, precipitated from the solution as a result of an inflow of edge waters from the north-west.

2) Calcite composing the cement of dolomites, mostly of the intergrowth type, apparently mainly secondary, precipitated from the solutions. In the peripheral semi-halo the precipitation of this calcite may be related to the inflow of the same edge spirifer waters, while in the holes within the oil-bearing area it may have been also formed without any direct relation to the latter.

3) Calcite associated with some skeletal remains of organisms, possibly in part also secondary (filling of leaching voids), but in part apparently corresponding to the recrystallized primary $CaCO_3$ of the skeletons of organisms.

The precipitation of $CaCO_3$ from edge waters in this case seems to be caused by a gradual increase of all the soluble salts, in particular of the soluble $CaCO_3$ and especially $CaSO_4$, with a gradual advance of waters according to bedding from the north-west and an increase of the depth from the day's surface. However, at the first moments of the meeting of the inflowing feebly mineralized edge spirifer waters with the more strongly mineralized waters of the halo about the periphery of the Buguruslan gas-oil field, the solubility of $CaCO_3$ might temporarily increase as a result of an increase of the NaCl content up to a certain limit, of the presence of appreciable amounts of Na_2SO_4 in the solution, and possibly of an increase in the CO_2 content. Nevertheless, upon a further approach of these waters, $CaCO_3$ must have rapidly precipitated from the solution.

Thus, an enrichment in secondary $CaCO_3$ may possibly be observed in two arch-shaped belts.

The calcite-bearing semi-halo should be understood only as a zone (possibly subdivided into two) enriched in secondary calcite, since the mineral calcite, in some quantity, is present throughout the territory of development of the carbonate facies of the spirifer substage.

IV. Gypsum (and anhydrite) in the Buguruslan region.

As shown by a petrographical study of the thin-sections of the oil-bearing rocks of the dolomite beds of the spirifer substage from the main operated fields, calcium sulphate as a component of the reservoir rocks is generally absent.

Here, in spite of a sufficiently high (up to 500—550 mg-equiv.) mineralization of the oil-bearing waters of the chlorine-magnesium type (in the Novo-Stepanovka and Zhuravlevka areas), the conditions of concentration, when estimating the composition of the dissolved salts, are generally insufficient for saturating the solution with $CaSO_4$. In the West- and East-Kalinovka areas, the mineralization of the bottom and edge water decreases (in most cases down to 240—320 mg-equiv.) (data by L. A. Guliaeva and A. I. Marenin, 1941) and it usually belongs to the sulphate-sodium type. In the author's opinion, formerly within the larger part of the Kalinovka areas the bottom water belonged to the chlorine-magnesium type.

Thus, it may be said that within the oil-bearing areas of Novo-Stepanovka and Zhuravlevka and in the petroliferous zone proper of the Kalinovka areas, no

calcium sulphate (in the solid phase) is generally observed. On the contrary, gypsum segregations are located along the NW, N and SW peripheries of the gas-oil field, i. e. in areas where the mineralization of the waters decreases (e. g. at Amanak down to 97 mg-equiv.) (data by A. I. Marenin, 1942) and they belong to the sodium-sulphate type.

The preservation even of a part of $CaSO_4$ and a fresh formation of gypsum in the rocks of the dolomite beds lying outside the contour (present or former) of the more strongly mineralized chlorine-magnesium waters may be accounted for by a sharp drop of the dissolved mass of NaCl, a different salt composition, namely a sodium-sulphate one, and an increase of the relative content of the SO_4'' ion of the less strongly mineralized waters of these areas (Guliaeva and Marenin, 1941), at which a saturation of the solution with $CaSO_4$ occurs more rapidly.

The presence of residual anhydrite grains in the gypsum brings us to the assumption that a certain part of $CaSO_4$ was contained in the rocks of the dolomite beds, especially in their upper portion, a long time since. Later on, under the action of an inflow of edge waters of a superficial origin (less strongly mineralized and with a lower temperature), there took place a hydration of the anhydrite to gypsum, followed by a precipitation from the solution of additional portions of gypsum with distinctly pronounced phenomena of cementation (gypsum cement of the intergrowth type).

The precipitation of gypsum from the solution may be related to an increase in the content of $CaSO_4$ dissolved, upon a gradual advance of the edge waters according to bedding deeper into the «massif» of Kazan deposits; especially favourable conditions might have been attained with the medium-mineralized sodium-sulphate waters of the north-western periphery and the halo around the gas-oil deposit.

Thus, the gypsum-bearing semi-halo should be understood as a zone of the carbonate facies of the spirifer substage, to a considerable extent only additionally enriched in $CaSO_4$.

V. Outlook for search in the Second Buguruslan.

The carbonate reservoir rocks of oil of the spirifer substage are developed in the main workable petroliferous areas of the Buguruslan region. From east to west an increase in the output of wells is observed, as well as a change from the pumping method of working (Novo-Stepanovka) to the flowing method (Kalinovka fields). All this is evidence of a distinct improvement in output and collecting properties, namely, of an increase of the permeability of the rocks of the dolomite beds of the carbonate series from the Novo-Stepanovka area to the Kalinovka areas. The above changes are caused by a regular change of the structure of the pore space of the carbonate reservoir rocks from east to west, namely, of very small- and fine-porous varieties of type IV (pores $\leq$ 0.02—0.03 mm) ([3]) to macroporous reservoir rocks with a structure of the pore space of type II and the corresponding varieties of type IV. This change of structure of the pore space is related, in the first place, to a somewhat different development of dolomite in the bottom sediments of different areas of the «spirifer» basin in the Buguruslan region, which fact should have influenced the course of the subsequent secondary processes. The development towards the west of the structure of the pore space of type II is evidence of the fact that here, in the first place, the cemented material has been dolomitized, the dolomitization of the cement beginning to decrease.

Reservoir rocks with a pore space of the I and III types ([3]) are observed both in the east and in the west.

The fact that the accumulation properties of the carbonate reservoir rocks of the spirifer deposits are worse in north-western direction (in the Amanak area), as well as at the northern and south-western peripheries of the Bolshoy Kinel uplift, is due mainly to a secondary precipitation of gypsum and calcite from the solution.

The phenomena of cementation and a simultaneous rise of the water-oil contact show that the north-north-western direction is unfavourable. On the other hand, the appearance in the north-west (Amanak) and in the west (Kalinovka)

of less strongly mineralized waters of the sodium-sulphate type justifies us in expecting somewhere here the western termination of the Buguruslan gas-oil deposit.

Thus, the west-south-western and generally western direction, provided a cover of hydrochemical deposits is preserved here (or an independent one), deserves attention from the standpoint of search for and drilling of favourable tectonic structures, in other words, of new oil deposits of the «Second Buguruslan» type.

The attention paid to the direction is in accordance: 1) with the nature of the primary facial changes (increase of the clay content towards the east-north-east; 2) with the diagenetic nature of the distribution of dolomite (its lesser part in the cement of dolomites in the western areas); 3) with a rise of the water-oil contact; 4) with the mainly secondary nature of the phenomena of cementation (gypsum and calcite) in a wide semi-halo surrounding the Buguruslan gas-oil field on the part of the inflowing and surrounding edge waters.

If in the western direction there are favourable closed (be it even relatively) tectonic structures, it may be expected that, similarly to the Buguruslan structures, they will have sufficiently strongly mineralized waters (of the chlorine-magnesium type), sufficiently porous reservoir rocks deprived of Ca sulphate and, hence, economic accumulations of shallow-lying oil in the carbonate deposits of the spirifer substage of the Kazan stage.

Received
28. VIII. 1943.

REFERENCES

[1] G. I. Theodorovich. C. R. Acad. Sci. URSS, XXXIX, No. 3 (1943). [2] G. I. Theodorovich, ibid., XXXIV, No. 4—5 (1942). [3] G. I. Theodorovich, ibid., XXXIX, No. 6 (1943).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

GEOLOGY

ON THE LITHOLOGY AND PALAEOGEOGRAPHY OF THE CARBONIFEROUS DEPOSITS OF THE NORTH-EAST OF THE DONETZ BASIN

By N. V. LOGVINENKO

(Communicated by P. I. Stepanov, Member of the Academy, 13.V.1943)

The Carboniferous deposits of the north-east of the Donetz basin (Belaya Kalitva) belong to the Middle and Upper Carboniferous—the series C_2^3, C_2^4, C_2^5, C_2^6, C_2^7, C_3^1 and C_3^2. The lower five series correspond to the Westphalian, and the upper two, to the Stephanian stage of the Carboniferous. The boundaries of the middle and upper divisions are established according to the N_1 limestone. The total thickness of the Carboniferous deposits attains 5000 meters.

The Carboniferous deposits are represented by different types of clastic, carbonate and carbonaceous rocks.

Among the clastic rocks all types are encountered, from conglomerates to finest argillaceous rocks. The most widespread are argillaceous rocks, in which an accumulation of clayey minerals, micas, iron compounds and carbonaceous matter takes place. Among the argillaceous rocks in series C_2^5 and C_2^6, lenses and bands of gypsum of a syngenetic origin have been encountered, which are accompanied by groups of layers of variegated shales.

These are followed by arenaceous rocks, in which there takes place a concentration of quartz, feldspars, and fragments of various sedimentary rocks (flint, flint shale, lydite, clay shale, sandstones and limestones).

The clastic rocks are diversified as to their textural and structural peculiar features. Among the latter, different types of cross-bedding should be noted: cross-bedding of the type of periodical streams, of the coastal-marine type, of the ripple-mark type, etc. Mention should be made also of the «curled texture» of the argillaceous and arenaceous rocks of the floor of coal seams, which are of importance when distinguishing the facies.

Among the carbonate rocks, micro-grained limestones are the most extensively developed. These are followed by organogenic limestones: brachiopod, foraminiferal, algal, coralline and their various combinations. Dolomitized limestones are in general rare and have been met within the C_2^5 and C_2^6 series only.

Carbonaceous rocks are represented by coal seams (stone coals and semi-anthracites) and different carbo-argillaceous and carbonate-coaly transitionary types. Among the coals and carbonaceous rocks there occur lenses, bands, and concretions of pyrite, marcasite, dolomite and spherosiderite, and sometimes bands consisting entirely of leverrierite, among which fragments resembling volcanic glass have been encountered.

The rocks described have suffered diagenation and partly metamorphization, which fact is manifest in their structural and textural features and mineralogical composition (schistosity, cleavage, etc.).

In the rocks studied up to sixty minerals are present.

Light fraction minerals, allothigenic: quartz, albite, oligoclase, microcline, orthoclase, kaolinite, muscovite, coaly matter. Authigenic syngenetic minerals: chalcedony, quartzine, secondary quartz, calcite, gypsum, coaly matter. Authi-

genic epigenetic minerals: minerals of the diagenesis, metamorphism and recent weathering processes: leverrierite, monothermite, sericite, graphitized coaly matter, calcite, spherulitic quartz, amorphous silica, chalcedony, quartzine, gypsum, secondary albite.

Heavy fraction minerals, allothigenic: zircon, tourmaline, rutile, apatite, garnet, brookite, anatase, augite, enstatite, hypersthene, diopside, hornblende, actinolite, xenotime, monazite, sphene, biotite, lepidomelane, chlorite, chloritoide, staurolite, sillimanite, corundum, epidote, spinel, fluorite, picotite, magnetite, ilmenite. Authigenic syngenetic minerals: dolomite, siderite, pyrite, marcasite. Authigenic epigenetic minerals: minerals of the diagenesis, metamorphism and recent weathering processes; secondary—tourmaline, rutile, anatase, brookite, chlorite, leucoxene, hematite, limonite, barite, goyazite.

Of the minerals named, augites and hornblendes are developed in carbonate rocks. The largest zircon accumulations have been encountered in arenaceous rocks with a cross-bedding of the stream type. Of the secondary minerals, barite and goyazite have been found only in organogenic limestones. Titanium dioxide minerals are concentrated in clayey rocks. Of the minerals listed above, in the rocks of the Donetz basin the following have been described for the first time: goyazite, monothermite, leverrierite, quartzine, and spherulitic quartz.

Chemical analyses of the different types of rocks have shown the following common elements to take part in their composition: O, Si, Ti, Al, Fe, Ca, Mg, Na, K, H, S, C. Great interest belongs to the composition of the argillaceous rocks where a concentration of Al, H and Ti takes place (Al_2O_3 up to 30—35 per cent, H_2O up to 17 per cent, TiO_2 up to 1.5—2.0 per cent). Spectroscopic studies have revealed the presence of the following elements: Zr, Hf, Ge, In, Ni, Cr, Cu, V, Be, Ba, Sr, and of some rare-earths. A concentration of Zr, Hf, Cu, V takes place in limestones of great thickness with a cross-bedding of the periodic stream type; a concentration of Ba, Sr and partly V, in limestones; a concentration of Cr and Be, in clayey rocks.

The rocks studied belong to three groups of facies:

a) A continental group of facies: sandstones with a cross-bedding of the periodic stream type, arenaceous and argillaceous rocks of the floor of coal seams, and coals.

b) A coastal marine group of facies: sandstones with a cross bedding of the coastal marine type, of the ripple-mark type, etc. Argillaceous rocks of stratified and non-stratified texture with pyrite, siderite and fauna of a freshened sea (pelecypods).

c) A marine group of facies: different limestones and argillaceous rocks with a marine fauna—brachiopods, foraminifers, etc.

In the sections of Carboniferous deposits studied, a regular recurrence of sediments of different facies is observed—the so-called cyclicity or rhythmicity of sedimentation, caused by continuous oscillatory movements of the area of the region during the deposition of the Carboniferous strata.

The beginning of each cycle of sedimentation is presented by thick continental sandstones with a cross-bedding of the periodic stream type, overlying the eroded surface of the subjacent strata. Their deposition takes place subsequent to the elevation at the epoch of continental erosion.

In the subsequent period, with a stable position of the sea level, there occurred an accumulation of the clay underlying the coal and of the coals themselves in the peat bogs of the coastal lowlands. The moment of coal accumulation was followed by a subsidence—an encroaching of the sea, in which shallow-water marine sediments were deposited up to a new elevation, completing the cycle.

In the section studied, from limestone H_6^1 to O_6, fourteen cycles of similar kind are distinguished (the bases of which are over limestone H_6^1, over coal k_5^1, k_5^1, over limestone K_7, K_9, K_9^0, M_1^1, M_6, over coal m_8, over limestone M_{10}^1, N_4, O_3 and O_4) where the eroded surface of the subjacent strata is overlain by thick continental sandstones with a cross-bedding of the periodic stream type, against the background of which a numerous series of cycles of the II and III order are developed, caused by oscillatory movements of small range (an alternation of marine sediments of different depths, continental and coastal-marine ones).

The elevations correspond to the beginning of each new cycle, and are marked by an unconformity in the sedimentary deposits. They bring new rock massifs to the area of erosion within the supplying province, which is manifest in the appearance in the sedimentary deposits of new associations of accessory minerals, associated with the beginning of a new cycle of sedimentation. The latter fact enables us to subdivide the section studied into series characterized by definite associations of accessory minerals. Not every cycle, however, shows an association of minerals which distinguishes it from the others; this is caused, first of all, by the fact of washing of the underlying series, which proceeds according to the principle of the so-called «inherited sedimentation» (Baturin) implying no conditions for the accumulation of new minerals. Therefore in the section studied, only eight series are distinguished. The boundaries of the series coincide with those of the cycles: I series H_6^1—k_2^1; II series k_2^1—K_7; III series K_7—M_1^1; IV series M_1^1—M_6; V series M_6—m_9; VI series m_9—N_4; VII series N_4—O_4; VIII series O_4—O_6.

The boundaries of cycles and series, as a rule, coincide or pass near those of the stages, zones and subzones, which are distinguished on the basis of the fauna and flora they have been found to contain.

In the subdivision of the section studied, the following minerals have been of correlative value: pleochroic apatite, garnet, anatase, brookite, aegirine, augite, diopside, hornblende, xenotime, monazite, sphene and chloritoide. The remaining minerals are either common, such as zircon, tourmaline, rutile, ore and coloured micas, or very rare, such as fluorite, epidote, etc.

The association of accessory minerals of the III series K_7—M_1^1 has been traced throughout the north-eastern part of the basin and found to be similar everywhere.

Within the territory of the whole basin the mineral association of this series varies, which permits three terrigenous-mineralogical provinces to be distinguished.

I. Northern province: apatite-garnet association with xenotime, monazite, corundum, and chloritoide.

II. Eastern and north-eastern province: garnet-xenotime-monazite-apatite association with anatase, brookite, and sphene.

III. Central and south-western province: anatase-brookite-corundum-monazite association with hornblende and chloritoide.

A study of the petrography and mineralogy of the sediments, as well as of the general geological conditions of the basin, permit the following conclusions of palaeogeographical nature to be made:

a) The area of origin of the clastic material—the supply province of the Carboniferous sediments of the basin—is the Ukrainian crystalline platform. No supply of material from the Voronezh massif and south-eastern regions took place.

b) The bulk of the clastic material was carried in by some small rivers which ran from the west, south-west and south. The deposition of the material took place on the coastal plain, in the estuaries of rivers, and under marine conditions, in the shelf area of a shallow sea.

c) The climatic conditions were characterized by an alternation of arid and moist periods, during which an accumulation of beds lying between coals, and of coals themselves was proceeding.

d) An accumulation of a thick series of Carboniferous sediments was the result of continuous oscillatory movements of the territory of the basin, that proceeded against the background of a general subsidence of the bottom of the geosyncline.

e) The most important elevations which caused great erosions (e. g. the erosion over M_1^1 and others) were confined to the upper portion of the middle division, and were probably due not only to epeirogenic, but to orogenic movements as well. The latter may be compared with the Malevrian movements of North England and the movements of Silesia (Jucks-Browne, Bubnoff).

Institute of Geology,
Kharkov State University.

Received
13. V. 1943.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

MICROBIOLOGY

SALIVARY SECRET OF THE APHIS *MYZUS PERSICAE* SULZ. AND ITS ABILITY TO FORM A FILTERING APPARATUS

By K. S. SUKHOV

(Communicated by L. A. Orbeli, Member of the Academy, 27.VI.1943)

The aphis *Myzus persicae* is a cosmopolitan remarkable for its omnivorousness. The latter circumstance seems to be responsible for *M. persicae* being a vector of very many phytopathogenic viruses. Among these belong such viruses as that causing spindle tubers in potato (*Solanum virus* 12) and the *y*-virus of potato (*Solanum virus* 2), mosaic disease on pea (*Pisum virus* 1) and on bean (*Phaseolus virus* 1), the yellow dwarf of onion (*Allium virus* 1), the mosaic disease on cucumber (*Cucumis virus* 1), and many others ([2]).

Most of these viruses are transmitted by *M. persicae* in a mechanical way. The virus particles are adsorbed on the aphis' stylet when the latter penetrates the infested cells of the plant. If the insect migrates to a healthy susceptible plant, the virus particles are mechanically introduced on the stylet into the sound tissues and thus infest them.

In order to clear up in detail the inoculation of vegetable tissues by *M. persicae*, I investigated *in vivo* the mode of feeding of this aphis with the aid of a binocular magnifying glass, under upper (opaque) illumination.

Upon an object-glass there was placed a polished steel plate which was covered with a cross-section of an *Impatiens balsamina* stem, several mm in thickness. This section was carefully moistened with water and covered with a small piece of covering glass whose diameter was not to exceed that of the section. A few aphides previously kept without food for several hours were transferred on this piece of glass. Individual insects which got on the lateral surface of the section started sucking at once. The transparency of the tissues of balsamine and the light reflected by the steel plate made it possible to observe the stylet of the aphis as it penetrated the live cells.

The process of sucking may be described in the following way. For a while the insect looks for a spot to puncture, touching the epidermis with the tip of its proboscis. After having chosen the spot, it stops and makes a slight downward movement with the whole body, strengthening the pressure of the proboscis upon the epidermis. At the same time a gradual contraction of the proboscis takes place, owing to which the stylet is laid bare, and pierces the epidermis. In the subsequent the downward movement is repeated from time to time, thus inserting the stylet deeper into the tissues, while the proboscis continues contracting. Out of the six cases observed in five the stylet made its way through the tissue intracellularly, and in one case only its penetration was intercellular.

The mode of the stylet's movement inside of the cells proved to be a quite peculiar one. Having penetrated the cell, the stylet begins to produce rapid swinging movements with its tip. Getting into the narrower parts of the cell, the range of those movements becomes narrower on account of the resistance of the cellular walls it hits against, without however injuring them. After it reaches the cellular wall perpendicular to the direction of its progressive motion, the point

of the stylet stops fixing the wall. Then, making a slight vibratory movement, the stylet pierces the cellular membrane, and its swinging movements are reassumed in the next cell.

The stylets of separate individuals could thus be observed to make within 20—30 minutes their way through five or six layers of cells (from the surface). The point of the stylet stayed in a cell for about 3—5 minutes. No deeper insertion of the stylet was observed; occasionally, the insect made a backward movement, and pierced the epidermis at a new place. After the stylet had been withdrawn, a thin colourless trace consisting of the salivary secretion was left behind.

In the subsequent the process of elimination of the salivary secretion by aphides was investigated by us according to Storey's method (7). Starving aphides were placed in a small glass chamber, covered from above with a thin wax-plate several μ thick. Upon the outside of this plate were placed drops of saccharose which were covered with a covering glass. The apparatus was then placed under a microscope and the external surface of the wax-plate subjected to microscopic examination at medium magnification. Now and then the aphides pierced the wax-plate with their stylets, and at the moment the stylet penetrated the wax, a drop of salivary secretion ran out, which coagulated at once. Every next movement of the stylet was accompanied by the appearance of new portions of salivary secretion which seemed to envelop it as a transparent sheath. Separate portions of the secretion formed bead-like swellings all along this sheath. Thus throughout the process of sucking the stylet, including its point, moved inside this sheath, being isolated by its walls from the surrounding solution.

If we take into account that the formation of the salivary coagulate begins before the plate is pierced by the stylet, it becomes obvious that the aphis receives during the whole process of sucking a solution preliminarily filtered through the salivary sheath. The latter was tested by us for its impermeability. With this aim in view the saccharose solution was added a dense suspension of *Bacterium prodigiosum*. A scrupulous examination of empty sheathes from which the stylets had already been removed showed that the bacteria sticking all around the sheath were unable to penetrate within its canal. This should be taken to mean that while the aphides are sucking, the sheathes act as real bacterium filters.

Buchner (4) reports that having subjected to microbiological analysis the intestines of several aphis species, these were found sterile and yielding no bacterial growth on nutrient media. It may be supposed that in this case the sterility of the intestines was due to the filtering mechanism of the salivary sheath.

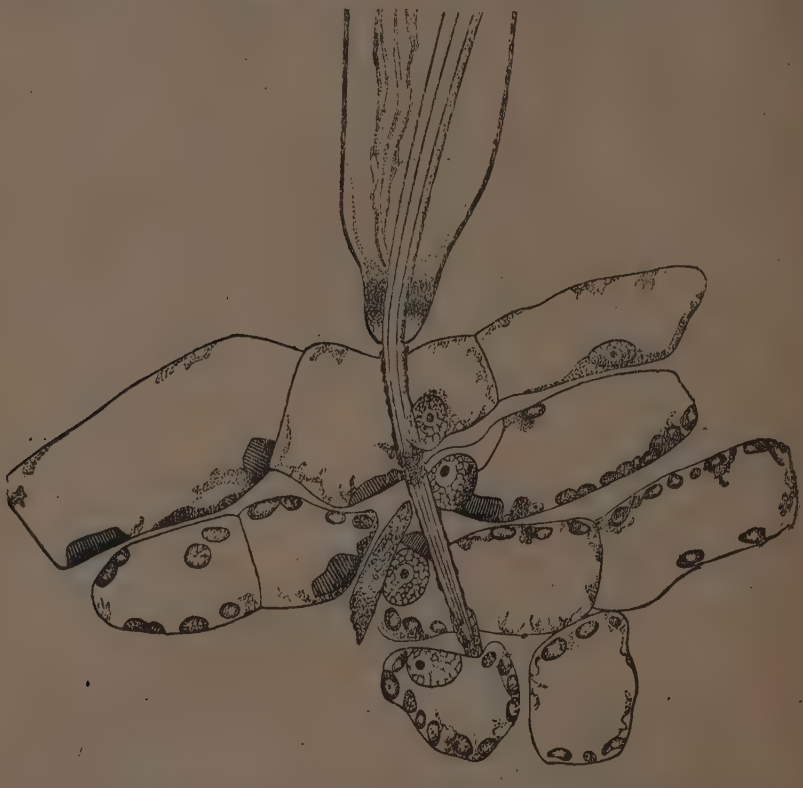
The chemical composition of the salivary coagulate was investigated by a number of writers on *Cicada* sp. It has been found to consist largely of proteins.

Thus, when sucking vegetable sap the aphis *Myzus persicae* receives it in a filtered state, without any mechanical suspension of solid particles. This seems to be an important adaptation, since the sucking canal of the aphides is very narrow, and the presence in the sap of particles in suspension might lead to its obstruction.

However, the salivary sheath may be ascribed a wider importance. The viscous proteinous gel it is formed of seems to adsorb and thus to impede the diffusion of number of substances, probably inclusive of some viruses. This may possibly account for the paradoxical fact that *Myzus persicae* which is the vector of many a virus, is unable to transmit such a stable and contagious virus as that of the tobacco mosaic disease. As shown by Hoggan, aphides *Myzus circumflexus* and *M. pseudosolani* are liable to transmit the tobacco mosaic virus from the tomato only, whereas these species are unable to transmit it from tobacco plants. As for *Myzus persicae*, it is found unable to transmit this virus from tomato plants either (5).

According to data by Rischkov and Smirnova, a purified virus of tobacco mosaic, if its solution be transferred into a colloidal medium (solution of starch, albumen), can aggregate into coarse liquid crystals (3). This aggregation is undoubtedly a factor which reduces the ability of the virus to diffuse through dense colloidal media. It may therefore be expected that the proteinous coagulate of the salivary secretion of aphides will prove impermeable or sparingly so to the virus.

By freezing aphides *Myzus persicae* at the moment they were sucking on mosaic leaves of tobacco plants, and by fixing them next together with the leaves, we were able to obtain paraffin sections, on which it was possible to trace the position of the stylet in the vegetable tissues and to determine its influence upon Iwanowski's crystals. Scheffield (6) assumes them to consist of the protein of tobacco mosaic



Cross-section through a tobacco leaf infected with mosaic disease. A stylet of *Myzus persicae* is seen to traverse cells with preserved Iwanowski's crystals

virus. Goldin (1) has shown that only those cells of a diseased tobacco plant are infectious which contain those crystals.

As may be seen from the figure, the stylet of *Myzus persicae*, when inserted in cells containing virus inclusions, does not induce dissolution of the crystals, even in the case of contact. This circumstance, as well as the data by Rischkov and Smirnova cited above, make more comprehensible the inability of *Myzus persicae* to transmit such a highly contagious virus as that of tobacco mosaic disease.

Laboratory of Plant Virus Diseases.
Institute of Microbiology.
Academy of Sciences of the USSR.

Received
27. IV. 1943.

REFERENCES

[1] М. И. Гольдин, Микробиология, **7**, 9—10 (1938). [2] В. Л. Рыжков, Вирусные болезни растений, 1935. [3] V. L. Rischkov and V. A. Smirnova, C. R. Acad. Sci. URSS, XXXI, No. 9 (1941). [4] P. Buchner, Tier und Pflanze in intrazellularer Symbiose, Berlin, 1921. [5] J. A. Hoggan, Phytopath., **19** (1929). [6] F. M. L. Sheffield, Proc. Roy. Soc. B., **126**, 529 (1939). [7] H. H. Storey, Proc. Roy. Soc. B., **125**, 455 (1938).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

PLANT PHYSIOLOGY

AGE VARIATIONS OF COLLOID-CHEMICAL PROPERTIES OF PROTOPLASM IN VEGETABLE CELLS

I. VARIATIONS OF PERMEABILITY AND VISCOSITY OF THE PROTOPLASM IN THE CELLS OF ONION SCALES AND HEADS OF CABBAGE

By N. A. MAXIMOV, Corresponding Member of the Academy, and L. V. MOZHAEVA

The problems bearing on the ontogeny of a vegetable organism have, especially since the appearance, though in a somewhat unfinished state, of Krenke's theory of cyclic ageing of plants ([3]), been inviting an ever increasing interest. Nevertheless, until recently they were treated largely on the ground of morphological material. Yet, in order to permit of a fuller and deeper insight, those age variations of physiological nature should be studied which proceed in the principal substratum of life phenomena, the protoplasm. It is absolutely imperative that those variations be studied not on a fixed killed protoplasm, but on a living one, and so far as possible unaffected by any procedure. The colloid-chemical properties of the plasm being one of the most important indices of its physiological condition, the authors decided to carry out some investigations in this line. Their aim was to clear up the variations of permeability and viscosity of the protoplasm taking place with age. Literary data on the subject are rather scanty and contradictory. Thus, in his experiments with *Spirogyra* Weber ([10]) found the protoplasm of young cells to be less permeable to the urea than that of older ones. Unlike this, Strugger who investigated the properties of onion cells, and Kolossov ([2]), who investigated the properties of root cells at various age, revealed in young cells a higher permeability to dyes than in old cells. According to a number of authors, the viscosity of the protoplasm of vegetable cells increases with age ([1,4–7, 9]). On the other hand, Strugger ([8]) reports that meristematic cells and fully grown, ageing cells show a lower viscosity as compared to cells at the stage of elongation. One of the causes of this discrepancy lies probably in the variety of the material used for investigation, and of the procedures applied. But anyhow, it points to the necessity of a more systematic treatment of the problem.

As material for our investigation we chose bulbs of the common onion (variety Danilovsky 301), and heads of red cabbage. The convenience of the material consists in that any bulb and any cabbage head offers simultaneously leaf organs of different ages: younger in the centre, and older towards the periphery. Moreover, the epidermis of the scales of the bulb is a classical object for investigating the properties of living protoplasm.

The permeability of the protoplasm was measured by two methods: 1) According to the electric conductivity of the water into which definite aliquots of leaves or pieces of leaves of a definite size were immersed; the water had previously been distilled in the usual way and the leaves were kept in it during 3 hours. 2) According to the duration of plasmolysis, solutions of saccharoze, KNO_3 and of

urea at various concentrations being used as plasmolytics. The two former were to characterize the permeability of the protoplasm to water according to how rapidly the latter abandoned the cells. Urea was chosen as a substance which penetrates through the protoplasm with relative ease, and as an index of the rate of its passage through the protoplasm served the time of deplasmolysis of the cell in its solutions. The method has been described in detail by Strugger.

In our experiments with saccharose by the time of plasmolysis we understood the period of time that elapsed until the volume of the protoplast ceases to diminish, which could be recorded by way of drawing the course of plasmolysis with the aid of Abbe's camera lucida. In the tests with KNO_3 the time of plasmolysis was supposed to coincide with the complete rounding out of the protoplast.

The results of the experiments with measurements of electric conductivity are summarized in Table 1 for onion, and in Table 2, for cabbage. The scales in onion and the leaves in cabbage were enumerated beginning with the external, oldest leaves, towards the central, young ones; only perfectly fresh and turgescent leaves and scales were taken, while such as showed signs of wilting were put aside.

Table 1

Exosmosis of Electrolytes from Onion Scales of Different Age ($K \times 10^{-5}$)*

Order of scales	Replication									
	1	2	3	4	5	6	7	8	9	10
1	157	106	142	139	176	168	136	128	136	190
2	101	116	103	122	175	231	164	185	190	178
5	97	84	116	88	206	260	326	175	278	260
7—9	135	125	481	257	213	481	582	429	305	294

Table 2

Exosmosis of Electrolytes from Cabbage Leaves of Different Age ($K \times 10^{-5}$)

Order of leaves	Replication					
	1	2	3	4	5	6
1	56	46	141	150	79	26
2	34	31	51	136	60	98
5	33	28	65	122	63	84
7	22	18	65	139	—	128
9—11	349	324	96	142	150	190
Very young leaves	420	—	154	471	—	—

As may be seen from the tables, the most intense exosmosis of electrolytes into the surrounding water, i. e. the highest permeability, is shown by the youngest scales of onion, or by cabbage leaves which were the closest to the centre of the organ. The next older leaves or scales show a lower degree of permeability. But the oldest leaves of a cabbage head forming the outer layer become more permeable again. In onion scales this increase is to be noticed only in separate cases (1st and 3rd replications), and is less conspicuous. To our opinion, this should be explained by the fact that in autumn when our experiments were carried out, even the external scales of the bulbs showed no sufficiently pronounced ageing phenomena.

Table 3 gives the duration of the plasmolysis of the cells of onion scales of different age in solutions of saccharose and KNO_3 and of the deplasmolysis of urea solutions. As may be seen, the time taken by either of the processes is the shortest in youngest cells, while it increases with their age. Consequently, the permeability of the cells, both to water and urea, increases with age. No second maximum of permeability in the oldest cells has been recorded in these experiments. Aside

* K is value of the specific electric conductivity of the solution.

Table 3

Duration of Plasmolysis and Deplasmolysis (in minutes) of Cells of Onion Scales in Different Solutions

Order of scales	Saccharose—plasmolysis						KNO_3—plasmolysis			Urea—deplasmolysis		
	0.6	0.7	0.8	0.8	0.8	0.8	1.0	0.8	0.8	1.0	0.9	0.9
1	85	111	92	75	90	110	62	52	54	443	422	387
3	60	42	20	—	—	55	43	29	29	405	342	294
4	—	—	—	25	37	25	—	—	—	—	—	—
5	45	39	—	—	—	15	26	14	17	227	139	173
7	25	5	15	—	15	0	15	7	11	81	55	67
8	—	—	—	0	—	—	—	—	—	—	—	—
9	—	—	0	—	—	—	7	—	4	—	—	—

from this, the results of the experiments on determination of the time of plasmolysis are in good agreement with those of the rate of exosmosis of the electrolytes from cells of different age.

Now let us pass to the observations on the age variations of viscosity, estimated according to the changes in the form of plasmolysis in saccharose solutions (Table 4). The observations were carried out with the same material as those concerning the duration of plasmolysis.

On the ground of the observations on the form of plasmolysis, and their comparison with the time of plasmolysis obtained by measurements, it should be pointed out that in the cells of the external, i. e. oldest, scale the shrinking of the protoplast proceeds at the lowest rate; the rounding out of the protoplast is very slow, too. In this connexion the form of plasmolysis usually remains concave. In the cells of the next, younger scales, the contraction of the protoplast proceeds more rapidly, and the rounding out sets in sooner; the plasmolysis form gradually becomes convex. However, in the youngest of the cells examined, viz. in those of the 7th and 9th scales, although the plasmolysis sets in very soon and is complete within 1—2 minutes, nevertheless the protoplast preserves during a rather long period its angular or spasmodic form, being in several points connected with the cell wall. We tried several times to keep the cells during 24 hours in the plasmolysing solution, but the picture remained unchanged. And if we were to estimate the duration of plasmolysis after its rounding out rather than by the rate of shrinking of the protoplast, we should instead of putting it at zero, as it has been done in Table 3, denote it by infinity.

In KNO_3 solutions the protoplasts subjected to plasmolysis have at first irregular outlines, but finally they nearly always assume a convex form. And they round out the sooner, the younger are the cells: at the highest rate, within a few minutes, rounding-out proceeds in cells of the 7—9th scales.

According to common view (5), the slower rounding out of the protoplasts of older cells of the external scales during plasmolysis, and their persistent preservation of irregular form points to a higher viscosity of their protoplasm, as compared to younger cells, and consequently to its lower hydrophily. As to the youngest cells of the 7—9th scales, their rapid loss of water during plasmolysis both with saccharose and with KNO_3 points to a more hydrophilous character of their protoplasm. The angular and even spasmodic form of plasmolysis in these cells should, to our opinion, be put down not to the higher viscosity of their protoplasm, but to the fact that at this period the cell wall is not yet completely isolated from the protoplasm, being closely connected with the latter (6). When using for plasmolysis KNO_3 solutions, we did not observe such a close connexion between the protoplast and the cell wall, because the ions of this salt increase the hydrophily of the plasm and facilitate its isolation from the wall. Using solutions of glycerine and urea, we observed also a more rapid rounding out of the protoplasts in young cells as compared to old ones, which points to their higher viscosity.

Table 4

Plasmolysis Form of Cells of Onion Scales in Saccharose Solutions

Order of scales	0.6 min.	0.7 min.	0.8 min.	0.8 min.	0.8 min.	0.8 min.
1	Angular, passing into convex	Angular and concave; rounding slow	Concave; no rounding	Concave; rounding after 20 min.	Concave, spasmodic; rounding slow	Concave and angular; rounding very slow
3	Angular, rapidly passing into convex	Angular and concave; rounding in 1 hour	Concave and angular; rounding	—	—	Angular; rounding
4	—	—	—	Angular; rounding after 3 min.	Concave and angular; rounding sets in soon	Slightly angular, rapidly passing into convex
5	Convex	Angular and concave; rounding in 40 min.	—	—	—	Do
7	Convex	Angular; no rounding after 2 hrs	Angular; slow rounding (2 hrs)	—	Angular; rapid rounding	Angular plasmolysis sets in almost directly, persists throughout experiment (2 hrs)
8	—	—	—	Spasmodic plasmolysis directly after immersion	—	—
	—	—	Spasmodic; no rounding after 5 hrs	—	—	—

Our experiments thus show that the youngest cells contain the least viscous protoplasm, and that viscosity increases along with the growth and ageing of the cells. The increase of protoplasm viscosity with the ageing of the cells points to its becoming less hydrophilous, which is in perfect agreement with the results obtained by other authors who were using quite different methods. We failed to observe a second minimum of viscosity in the protoplasm of old cells that would run parallel to the increase in the permeability of the protoplasm by water and electrolytes, as observed by us in cabbage.

K. A. Timiriazev Institute of Plant Physiology.
Academy of Sciences of the USSR.
N. G. Chernyshevsky University at Saratov.

Received
27. IV. 1943.

REFERENCES

[1] П. С. Ерыгин, Научно-агрономич. журнал, 280 (1930). [2] И. И. Колосов, Сов. агрономия, 5, 43 (1939). [3] Н. П. Кренке, Теория цикличн. старения и омоложения растений и практич. ее приложение, 1940. [4] J. Belehradek, C. R. Soc. Biol., 92 (1926). [5] N. Cholodny and E. Saikewitsch, Protoplasma, 20 (1933). [6] E. Gratzy and F. Weber, Protoplasma, 12, 559 (1931). [7] A. Smirnov, Planta, 6, 687 (1928). [8] S. Strugger, Jahrb. d. wiss. Botanik, 79, 406 (1934). [9] H. Timmel. Protoplasma, 3, 197 (1928). [10] F. Weber, Protoplasma, 12, 129 (1930).

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

PLANT PHYSIOLOGY

ON THE MECHANISM OF THE ACTION OF HETEROAUXIN

By A. A. PROKOFIEV

(Communicated by A. N. Bach, Member of the Academy, 5.VI.1943)

Root rubber-plants such as tau-saghyz, kok-saghyz and krym-saghyz are known to be propagated by seed. If vegetative propagation of some of them is possible, it is so within a rather narrow range. As to such a rubber-yielding plant as tau-saghyz, its cuttings give in general but a negligible ratio of rooting. At the same time all the rubber-plants listed and tau-saghyz in particular are endowed with an extremely high ability to restore deficient overground parts. A plant with an intact root system may during a long period of time have its upper root horizons regularly cut-off, and nevertheless form anew a sufficiently strong overground mass as soon as the surgical intervention is over. Even small root cuttings 1—2 cm long, when planted into sand or soil, will soon yield numerous leaves. The cuttings, however, do but poorly develop roots, if at all. Thus, the first which strikes one who would attempt to propagate root rubber-plants by cuttings is a definite disharmony between their leaf and root formation. Because of this disharmony the cuttings usually develop leaves soon upon planting, but perish after a short while for lack of roots. It is this circumstance that we believe to have been responsible for the dying-away of the kok-saghyz cuttings during the field tests of 1941.

There is a definite relation between the rubber yield of the plants and their rooting ability. Tau-saghyz which is the highest in rubber and has a low rate of growth develops scarcely any root when propagated by cutting. Whereas krym-saghyz which is much poorer in rubber, but shows a higher rate of growth, is rooting much better. Microchemical determination of carbohydrates (sugar, inulin) has shown that reappearance of leaves leads to a rapid consumption of the carbohydrate reserves of the cutting. It is most probable therefore that after the leaves reappear, the cutting fails to root for lack of the necessary building material that has been spent on leaf formation.

To the author's opinion, in order that cuttings of tau-saghyz and to a somewhat lesser degree those of other rubber-plants be able to develop roots, it is necessary to inhibit the formation of leaves. However, since literature contains no information which would point to the existence of some agents suppressing leaf formation in cuttings, we decided to solve the problem by stimulating root formation. Our aim was to reduce the difference between the rate and energy of root and leaf formation, and thus to make the cutting develop roots. As a «root-forming» agent use was made of the β-indol-acetic acid (heteroauxin) of native production. The use of heteroauxin in order to stimulate rooting in various poorly rooting plants is known to enjoy wide application. In spite of this fact, the way in which heteroauxin affects the vegetable organism still remains obscure. From numerous papers ([1–5]) devoted to the effect of heteroauxin upon cuttings of various plants, it may be seen that treatment with heteroauxin results in a dislocation

Table 1

Zone of root from the neck downward in cm	Control (well-water)				Heteroauxin 0.5%				Heteroauxin 0.2%				Heteroauxin 0.1%			
	Cuttings				Cuttings				Cuttings				Cuttings			
	Formed		Healthy	Perished	Formed		Healthy	Perished	Formed		Healthy	Perished	Formed		Healthy	Perished
	roots	leaves			roots	leaves			roots	leaves			roots	leaves		
0—3	—	19	4	1	1	—	23	—	—	—	20	4	—	1	21	2
3—6	—	13	11	—	4	—	12	8	1	—	21	—	1	5	19	—
6—9	—	13	7	—	4	—	17	7	4	—	20	1	5	1	17	1
9—12	1	2	17	3	—	—	7	16	6	—	17	—	7	—	13	3
Total	1	47	39	4	9	—	59	31	11	—	78	5	13	7	70	6
Percentage	1.1	52.2	43.3	4.4	9.9	—	65.9	34.1	12.2	—	86.6	5.6	14.4	7.8	77.8	6.7

Zone of root from the neck downward in cm	Control (well-water)		Heteroauxin 0.5%		Heteroauxin 0.2%		Heteroauxin 0.1%	
	Cuttings		Cuttings		Cuttings		Cuttings	
	Total		Total		Total		Total	
0—3	24		24		24		24	
3—6	24		24		25		25	
6—9	20		25		25		24	
9—12	23		23		23		23	
Total	91		96		97		96	
Percentage	100		100		100		100	

and mobilization of nutrient substances and, in the first line, of carbohydrate and nitrogenic reserves of the cutting. Externally the effect of heteroauxin is to promote the formation and development of the roots, the latter being often observed in such cuttings as fail to root under normal conditions. Treatment of cuttings with heteroauxin is usually practised either by covering the cutting with a layer of lanoline-paste containing a definite quantity of heteroauxin, or by soaking them in water-solutions of heteroauxin. For the treatment of cuttings of root rubber-yielding plants we chose the latter procedure. The cuttings were immersed into a solution of heteroauxin either with their basal parts, or entirely, according to the experimental set, after segments of roots 3 cm long were preliminarily wilted in the open air. The degree of wilting was controlled visually; as a rule, it was carried on until the turgor of the tissues was reduced to such a point that an injury of the cutting with a knife or a razor ceased to call forth any outflow of latex. The time of treatment of the cuttings with heteroauxin solutions varied from 3—4 to 20 hours. After being removed from the solution, the cuttings were thoroughly washed in water, slightly dried with a towel, and horizontally arranged upon sand. From above the cuttings were covered with a layer of sand some 2 cm thick. The sand was kept moist by daily waterings. As control, in all experiments well-water was used, in which the cuttings were kept as long as the experimental ones were kept in the heteroauxin solution.

The aim of the first experiments carried out with tau-saghyz cuttings was to find out the relation between the concentration of heteroauxin in the solution and the formation of roots by the cuttings. As heteroauxin might possibly produce a different effect upon cuttings taken from different zones, these were treated separately. Cuttings 3 cm long were prepared of roots of 5-month-old plants. Wilting was applied for 24 hours, treatment with heteroauxin solution of well-water for 4 hours. Records were taken 25 days upon planting of treated cuttings into sand. The results are summarized in Table 1.

The data contained in Table 1 permit us to make the following conclusions:

a) Treatment with heteroauxin appreciably enhances root formation in tau-saghyz cuttings, although the absolute number of the cuttings which developed roots is no large one: 1.1 per cent in the control against 6.2, 11.3, 13.6 per cent in different experimental sets.

b) At high concentrations heteroauxin brings about death of a considerable number of cuttings, those of the bottom horizons being the most susceptible to the treatment. This fact may possibly be accounted for by a smaller volume of the root-mass in the cuttings of these zones, owing to which they become more saturated with heteroauxin when treated.

c) Cuttings from the upper horizons are endowed

Table 2

State of cuttings at the time of record	Kok-saghyz								Krym saghyz							
	Well-water				0.2% heteroauxin solution				Well-water				0.2% heteroauxin solution			
	Zone of root				Zone of root				Zone of root				Zone of root			
	0–3	3–6	6–9	9–12	0–3	3–6	6–9	9–12	0–3	3–6	6–9	9–12	0–3	3–6	6–9	9–12
Cuttings with both leaves and roots	1	—	—	—	1	—	—	—	11	11	13	6	—	—	1	—
Cuttings without leaves and roots	—	—	—	—	9	3	10	5	—	—	—	—	10	16	12	10
Cuttings with leaves without roots	22	18	21	19	1	—	2	2	13	15	12	10	—	—	—	—
Healthy cuttings without leaves or roots	—	1	2	2	12	23	14	13	1	—	—	3	7	2	12	4
Perished cuttings	—	—	—	—	—	—	—	—	—	—	—	1	11	4	1	8
Total	23	19	23	21	23	26	26	20	25	26	25	20	28	22	26	22

Table 3

Cuttings, in %	Krym-saghyz				Dandelion				*Scorzonera hispanica*			
	Control	Heteroauxin			Control	Heteroauxin			Control	Heteroauxin		
		0.2%	0.1%	0.05%		0.2%	0.1%	0.05%		0.2%	0.1%	0.05%
Formed leaves	61	0	0	0	84	0	0	0	0	0	0	0
Formed leaves and roots	34	0	0	0	16	0	0	0	0	0	0	0
Formed roots per cutting: up to 5	5	0	0	0	0	0	19	10	39	12	22	18
Formed roots per cutting: 5–10	0	0	0	0	0	0	0	12	0	5	12	12
Formed roots per cutting: over 10	0	5	18	71	0	5	31	67	0	22	54	50
Healthy without roots or leaves	0	0	0	0	0	0	0	11	61	0	6	8
Perished	0	95	82	29	0	95	50	0	0	61	6	12
Total	100	100	100	100	100	100	100	100	100	100	100	100

with the highest ability to form leaves, and the lowest to rooting. Downward the root the capacity of cuttings to develop leaves decreases, and that to give roots, increases.

d) Of great interest is the influence of heteroauxin upon leaf formation in cuttings. While the control-cuttings developed leaves in 51.6 per cent of cases, the experimental cuttings treated with 0.5 and 0.2 per cent heteroauxin solutions were entirely devoid of leaves. Only the lowest of the concentrations tested, viz. those of 0.1 per cent, brought about, along with the appearance of roots, the formation of leaves in 7.3 per cent of the cuttings. Remarkable is also the fact that the cuttings develop either leaves or roots. Not a single case of simultaneous appearance of both roots and leaves in the same cutting of tau-saghyz could be observed.

Because of a number of biological features inherent in this plant, tau-saghyz stands somewhat apart among the rest of rubber plants. It seemed therefore of interest to find out in how far the regularities recorded for the cuttings of tau-saghyz hold for other plants, too. With this aim in view we subjected to a treatment with 0.2 per cent heteroauxin root-cuttings of kok-saghyz, krym-saghyz and tau-saghyz. The procedure was the same as described above. The age of the plants from which the cuttings had been taken was 5 months. Wilting lasted two 24-hour days on account of the low temperature of the room. Treatment with heteroauxin during 20 hours. As control well-water was used. Records were taken every 30 days upon treatment. The results are tabulated in Table 2.

As may be seen from the table, the treatment of cuttings with heteroauxin resulted both in kok-saghyz and krym-saghyz in an inhibition of leaf development. In kok-saghyz a certain increase in root formation was secured (28.4 per cent against the 1.2 per cent of the control). In krym-saghyz cuttings leaf formation was entirely suppressed by the treatment. As a result of heteroauxin treatment the cuttings of krym-saghyz formed roots nearly all along the surface of the cuttings. Both number and vigour of the roots formed exceeded by far those in the controls. An analogous effect of heteroauxin treatment was recorded for the cuttings of other plants (Table 3).

Noteworthy is the high death ratio among cuttings treated with high concentrations of heteroauxin.

Supposing that the difficulty to root-in cuttings of tau-saghyz and the rest of root rubber-plants may possibly be due to a deficiency of reserve substances, inclusive of some vitamins, we endeavoured to improve root development in them by treating tau-saghyz cuttings with various substrata. We thus tested the hydrolysate of bean seeds, infusum of wild rose fruits, solutions of glucose, asparagin etc. However, treatment with all the substances listed above gave no results, except for leaf formation. A parallel treatment with heteroauxin (0.025 and 0.05 per cent) produced again an inhibiting effect upon leaf formation, without, however, resulting in any important development of the roots (Table 4).

Table 4

Treatment of cuttings	State of cuttings				Total number of cuttings
	with leaves without roots	with roots without leaves	healthy without leaves or roots	perished	
Control (well-water) . . .	17	—	1	2	20
Infusion of wild rose . . .	34	—	2	1	35
Hydrolysate of bean seeds	32	—	—	2	36
Heteroauxin 0.025%+wild rose infusion	3	3	27	3	36
Heteroauxin 0.05%	2	3	29	2	36

As may be seen from Table 4, this experiment also bears evidence to that heteroauxin, even when applied at lower concentrations, suppresses the formation of leaves in cuttings. Microchemical determinations of sugars in cuttings have shown that large amounts of soluble sugars are contained only in such cuttings as have been treated with heteroauxin. In the rest of cuttings, irrespective of the treatment applied, the sugars disappeared by the time the records were taken. In this case the mobilization of the sugars is undoubtedly associated with leaf formation. By suppressing the latter, heteroauxin inhibits the consumption of carbohydrates, as well.

On the ground of the data secured, we arrive at a conclusion that the effect of heteroauxin upon the cuttings consists in the suppression of the processes that lead to leaf formation. As a result, the plastic substances available in the cutting may be mobilized for the construction of new roots. Plants that poorly form their adventitious roots, require higher concentrations of heteroauxin in order to suppress leave formation.

K. A. Timiriazev Institute of Plant Physiology.
Academy of Sciences of the USSR.

Received
5. VI. 1943.

REFERENCES

[1] O. Smith, L. B. Nach, G. E. Davis, Botan. Gazette, **102**, No. 1 (1940). [2] J. W. Mitchell and N. W. Stuart, ibid., **100**, No. 3 (1939). [3] T. R Alexander, Plant Physiology, 13 (1938). [4] М. Х. Чайлахян. Гормональная теория развития растений, 1937. [5] Н. Г Холодный, Фитогормоны, 1939.

Comptes Rendus (Doklady) de l'Académie des Sciences de l'URSS
1944. Volume XLII, № 5

PHYSIOLOGY

ON THE QUESTION AS TO THE MECHANISM OF DEATH CAUSED BY BURNS

By N. V. BEKAURI, A. A. DANILOV and E. A. MOISSEJEFF

(Communicated by L. A. Orbeli, Member of the Academy, 9.IX.1943)

One of those questions which are of equal interest both to physicians and biologists is that concerning the mechanism of death caused by burns. It is known that serious burns and in particular extensive, though even light ones, may be fatal even if no accessory complications, for example infection, arise. In the case of burns two critical moments are distinguished: the first within a few hours or a day upon the accident, and another, usually a week or two later when, after an apparent amelioration of its general conditon, the patient perishes suddenly (the so-called «late death»).

The clinical picture observed in the case of burns has been thoroughly investigated, as well as those biological changes that take place in the organism. Important work in this domain was done by Kalmanovsky, Underhill, Duval, Lambret — Drissens ([2—4]) and by many others. An extensive list of literature may be found in Riel's article ([1]).

The first period is characterized by general excitation, sometimes accompanied with convulsions and delirium, increased blood pressure, coagulation of the blood, hyperglycohaemia, leucocytosis, albuminuria. Soon these phenomena give way to an opposite picture: adynamia is developed, the blood pressure drops, hypoglycohaemia and leucopenia set in. A prolonged and profound disturbance in thermoregulation should be pointed out.

Alterations in the internal organs, liver, kidneys and spleen have also been described.

More than one theory have been advanced in order to explain all these phenomena. We will not discuss them here in detail; let us say only that at the time being the most important rôle is attributed to the resorption of the products of decay of the tissues, formed within the area injured.

Data are, however, available which point to the pain irritation being operative in the process.

In our investigation an attempt was made to approach the mechanism of development of the general phenomena ensuing in the organism after grave burns, and death caused by them from the standpoint of disturbances of the endocrine apparatus. The clinical picture shown by these patients is sufficient to make us think of essential endocrine changes.

This finds support in some literary data ([5—10]).

Special attention is due to alterations shown by the adrenals: hyperplasia of the medulla and alterations in the chromaffin cells have been reported. We decided to experimentally reproduce the changes that take place in the suprarenal bodies.

As test-objects white mice were chosen.

The method was the following. A lot of mice (10 individuals), usually from the same litter, were taken. With the aid of a thermocauter on all of them burns of the right half of the trunk were inflicted, extending from the fore limb to the hind one, to a distance of 0.5 cm from the medial dorsal and medial ventral line. The total area of the lesion was about 10—15 cm^2, according to the size of the animal.

Upon the operation which, as a rule, was accompanied with a sharp pain reaction, the mice were usually sitting motionless, sometimes they would lay on one side. In other cases the reverse could be observed: the mice were agitated, they were running about trying to get out of the cage, and peeping, etc. This excitation, however, was transient, giving soon place to the same phenomena of hypodynamia as shown by most animals. Their state gradually changed for the worse, the animals ceased to react upon a touch, sharp dyspnoe was developed, their hair became ruffled.

Part of the animals perished soon, about half an hour to an hour and a half after the operation. But in most cases death ensued within 3—7 hours of the experiment. Out of the whole lot (110 individuals) only 14 have survived and recovered.

The animals were autopsied directly after the death and their adrenals fixed with formalin or Ort fluid. Even when examined with unaided eye the suprarenal capsules of those mice that had perished 3—7 hours after the injury could be distinguished from normal ones. Instead of being a pale-yellow they assume a greyish-pink hue and become as it were semi-transparent. The adrenals of those mice which perished within less than 3 hours after the burn, did not look different from normal ones.

Although there was no difference between the two glands, we preferred to take the left one in order to prevent the possible objection that the alterations observed might have been due to a direct thermal effect of the burn. A microscopical examination of the adrenals revealed essential alterations: the blood vessels were found to be dilated and overfilled with blood, separate small haemorrhages occurred in the medulla.

But especially grave were the changes observed in the cortical substance. In those mice as perished not until 3 hours upon the burn and later there was a progressive reduction of the quantity of lipoids in the cells, which seemed to obey a definite resorption. Utterly devoid of lipoids was the *zona glomerulosa*; then, beginning with *zona reticularis* the lipoids seemed to be as it were washed out of the *zona fasciculata*. In intermediate cases the lipoids were found to be preserved in the external layer of *zona fasciculata* and in the shape of separate traces in isolated cell bands of the medium layer of *zona fasciculata*. In several cases when the death of the animals had ensued 6—7 hours after the burns, no lipoids at all could be discovered in the cells of the adrenal's cortical tissue.

In order to preclude the supposition that the picture observed by us might be due to *post mortem* alterations, we carried out a set of control experiments. Now we did not wait until the animals would have died, but killed them at definite periods after they had been cauterized (3—7 hours). Dissection and microscopical examination of the animals went to confirm our observations, although in those cases there was no such conspicuous reduction in the number of lipoids, and in none of the cases did we observe their total absence.

Such quantitative discrepancies may only be accounted for by the following reasoning: since one of the two animals perished of the burn inflicted upon it, while the other was killed at the same period after the injury, it is evident that in the latter case the injury happened to be not so grave for the animal (in so far as it did not perish by that time); consequently, it is quite natural that all the alterations would be correspondingly slighter.

Summing up the results of our investigations, the following can already be stated: the burn is a factor promoting the elution of the lipoids out of the cells of the cortical substance of the adrenals, which begins soon after the injury and reaches

its maximum within some 5—7 hours. The alterations revealed by us bear evidence of the fact that along with medulla the cortical substance of the adrenals also takes part in the pathogenesis of the general phenomena taking place in the case of burns.

The purpose of our subsequent work will be to investigate the rôle of the suprarenal capsules in relation with the rest of endocrine glands, in the first line with the pituitary body, and also to find out the influence of the nervous system, which is likely to permit of a deeper insight into the mechanism of death caused by burns.

I. P. Pavlov Physiological Institute,
Academy of Sciences of the USSR.

Received
9. IX. 1943.

REFERENCES

[1] Riel, Zbl. f. Haut.-Geschl. Krankheiten, **38**, 289 (1931). [2] Underhill, Kapsinow and Fisk, Amer. Journ. Physiol., **95** (1930). [3] Duval et Mourgue-Molines, Journ. Chir., **50**, 471 (1937). [4] O. Lambret et J. Drissens, Rev. de Chir., **75** (1937). [5] Berkow, Med. Journ. and Rec., **134**, 386 (1931). [6] R. J. Harris, Clin. Journ., **59**, 150 (1930). [7] L. Lattes, Arch. di Farmacol. sper. e Scienze affini, **49**, 324, Roma (1930). [8] C. Crema, Boll. d. Soc. med.-chir. di Modena, **80**, 209 (1929—1930). [9] H. Kisima, Fukuoka acta med. (Abstr. Sect.), **31**, 550 (1938). [10] W. Beyer, Monatschrift f. Unfallheilkunde u. Versicherungsmedizin, **47**, 101 (1940).

Prix $ 0.50